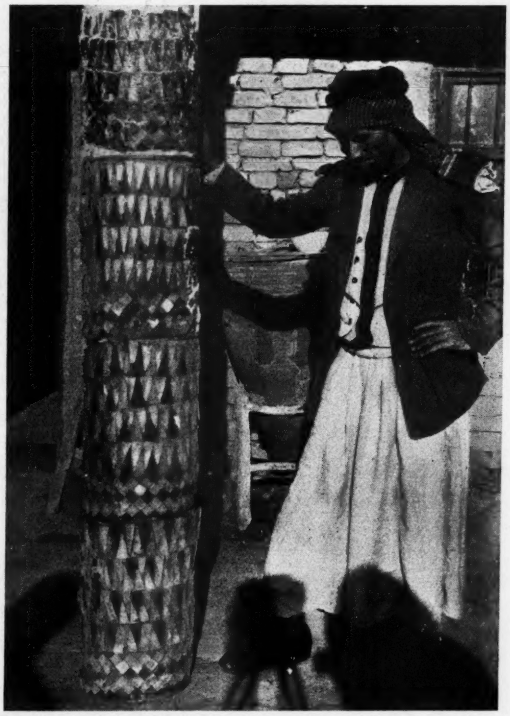
THE DISCOVERIES AT TELL EL OBEID

# DISCOVERY

## A Monthly Popular Journal of Knowledge

Vol. V. No. 57. SEPTEMBER, 1924. (Annual Subscription 12s.6d. Post Free). PRICE 1s. NET



PART OF ONE OF THE MOSAIC COLUMNS FROM THE NIN-KHURSAG TEMPLE.

CONTENTS

| | Pages. |
|---|---|
| Editorial Notes ... ... | 189 |
| The Discoveries at Tell el Obeid.—I ... ... ... ... | 191 |
| Measuring the Universe ... | 196 |
| The Botany of Our Coasts ... | 199 |
| The Use of the Ultra Microscope | 204 |
| Photographing Wild Elephants in Equatorial Africa ... ... | 206 |
| Jelly Fishes and their Relatives | 208 |
| Alchemy in Islam ... ... | 212 |
| The Use of Steam ... ... | 216 |
| A Thousand Miles up the River Amazon ... ... | 220 |
| Shooting the Wind ... ... | 222 |
| Power from the Poles... ... | 224 |
| Scottish Humour ... ... | 225 |
| Book Reviews ... ... | 227 |

# DISCOVERY

A Monthly Popular Journal of Knowledge

Vol. V. No. 57 SEPTEMBER, 1924. PRICE 1s. NET



Edited by Hugh B. C. Pollard.

Scientific Adviser: A. S. Russell, B.Sc.

Publishers: Benn Brothers, Ltd. All communications respecting editorial matters to be addressed to the Editor; all questions of advertisements and subscriptions to the Manager.

Offices: 8 Bouverie Street, London, E.C.4.

Telephone: City 9852 (6 lines).

Telegrams: Benbrolish, Fleet.

Annual Subscription, 12*s.* 6*d.* post free; Single numbers, 1*s.* net; postage, 2*d.*

Binding cases for Vol. IV, 1923, are now ready. Price 2*s.* 6*d.* net each; postage, 6*d.*

## Editorial Notes.

It was an American woman who voiced the great truth. She was staying at a small hotel, miles from anywhere, right on Exmoor where the railroads are a tortuous seventeen miles away. "You English," she said, "have got transportation down to a fine art. I can just go any place I want on a charabanc." It is a true bill. You can go almost anywhere in Great Britain on that objectionable conveyance. For better or worse we live in a charabanc age, and, as the wisdom of the countryside has it, "they could have been stopped at the beginning, but now they have come to stay."

* * * * *

Exmoor is not a kindly country for motors. Porlock and Lynton hills are still accounted test hills for even the most robust of cars. The road surface is execrable, and the garages at the foot of these climbs stock stretchers on which to bear unfortunate motorists to the cottage hospitals. Nevertheless, charabanc traffic flourishes. Inland, midway between Porlock and Lynton, lies a single second-class road deep at the bottom of a valley. The best approach to this is by a particularly long and dangerous hill with a gradient of one in five—Church Hill. I do not know a better deathtrap in Britain. The road is narrow, so narrow that should an ascending touring car meet another, one or the other has to back possibly a hundred yards or more until a recess is found where passing is possible. If you meet a charabanc, or a sequence of charabancs, passage is actually impossible. The width of the road is not sufficient to allow even a horseman to pass a broad-bellied Purple Peril bearing its cargo of Ilfracombe trippers to the disillusionment of the Doone Valley.

* * * * *

At the bottom of this hill is a hamlet, Rockford, where the charabancs stop and their occupants drink heartily at the inn to steady their disordered nerves after the perilous descent. There is no place in this narrow street where a modest two-seater car can pass the halted charabancs. The result is that residents in the villages along this road cannot be certain of getting to the local railway station at Lynmouth, unless they start an hour to two hours before the charabanc tide sets in. Three miles of road are impassable.

* * * * *

It seems incredible that the Ministry of Transport, who have access to the maps of the Ordnance Survey and presumably have power to stop this traffic, permit it to continue. A disastrous accident is inevitable, for Church Hill is notorious for the treachery of its surface, and the gradient is so severe that even with wheels firmly locked by the brakes a heavy car will slide uncontrollable down the declivity. Local practice acknowledges this, and cars are "locked into the ditch" at the top and slide down trusting to luck and hoping that nothing will meet them. The local police, a county force who do not enjoy the statutory powers of traffic control vested in our London Metropolitan Police, are powerless. They cannot even prevent the charabancs stopping at the bottom of the hill and blocking the whole road. It is a ludicrous situation. Everyone knows and fears the danger, but everyone has to wait until the necessary ghastly accident occurs before commonsense action can be taken by the far-away and irresponsible Ministry of Transport.

This is just one particular instance. There are doubtless scores of others in different parts of the country. But it typifies the whole modern problem of the new transport. Rendered down to its essentials there are only two ways of dealing with the problem. Either heavy traffic must be prohibited on dangerous second-class roads, or roads must be widened and made safe to meet the needs of modern traffic. The obvious solution is to prohibit such traffic until the roads are widened. Yet what is everybody's business is as usual nobody's business.

* * * * *

The traffic problem goes further. We may by using our open spaces in London as motor parks stave off congestion for a year or two, but that is purely a palliative. What is going to happen to traffic in our great cities? Firstly, the horse traffic must be suppressed or confined to definite hours. Not only traffic but sanitation will benefit from this. Absence of horses means a reduction in the number of flies and a consequent decrease of infantile mortality. Next comes the problem of the private car.

* * * * *

If the increase of motor traffic continues at its present pace the private car will become a nuisance which will have to be met. To-day, two opulent individuals in a limousine take up nearly as much road space as an omnibus capable of carrying forty people. It is possible that ten years from now the needs of the community will be so pressing that the convenience of the individual will have to be sacrificed, and we shall find that private car traffic will be entirely prohibited in congested areas. The private car owner will be able to bring his car to certain points, probably in the case of London a zone marked off by the underground railroad circle or omnibus termini, but no farther. Relief through routes skirting the congested area will accommodate through transport from north to south of the Thames. It is perhaps a disconcerting picture, but though one may put forward temporary palliatives there does not seem to be, short of the total reconstruction of London, any other means of meeting the problem. Transport is a problem and a vital one. It needs the application of high-efficiency brain-power, and, with all due deference to our excellent police force, it is a task for the organiser and the trained engineer rather than for the police executive.

* * * * *

They have done well in the past and they do their best at present, but in the interest of the ratepayer it is as well to point out that the use of a well-paid and moderately expensive civil force of police to control traffic is not absolutely essential. A new traffic control body, whose employees would have the same legal powers as, for instance, park-keepers (who in most cases enjoy the same legal authority as constables within their zone of duty), would do as well. The whole question of traffic needs reconsideration. It is not simply a question of tinkering up existing mechanisms and grudgingly meeting minor crisis after minor crisis after chaotic conditions have occurred. The whole problem needs tackling with a view to future rather than immediate conditions, and the best scientific brains and the best of organisers should be called in to meet the needs of the situation. As the wisdom of the countryside sums up the motor situation, "they have come to stay." It is no good deploring it. The only thing to do is to get on with the job and build roads and evolve traffic regulations that will avoid chaos, eliminate unnecessary danger and make for general progress.

* * * * *

I want to thank those many readers of DISCOVERY who have so kindly sent in the names and addresses of potential subscribers. In every case copies have been sent off and in most cases we have been justified in our faith in our paper and our readers. The recipients have become subscribers. *We will send a free copy of the paper to anyone who sends in a postcard asking for one. It does not matter how many names and addresses you send or how far off they are.* We believe that DISCOVERY appeals to the educated man and we know that if every present reader of the paper finds us another subscriber then the paper will be a sound and prosperous enterprise able to fulfil the objects of its founders and able to increase in size and influence. Is DISCOVERY on the table of your local institution or library? Do they take it at your boy's school? Is it in the waiting room of your doctor? They are all potential readers and, if you can give us this help, their names and addresses, we will see to it that a copy of the paper reaches them. We believe that personal recommendation is the surest way of reaching the right kind of people and further that it builds the best of all foundations. Pioneer work is always hard and difficult, but we on our side are working unremittingly to make this paper a success. The help that you can give us by bringing the paper to the notice of your friends and giving us a helping hand is extraordinarily valuable. Every new reader gained means far more than the subscription. It is a message of practical encouragement, a testimony that we are making sound progress and adding to our friends.

# The Discoveries at Tell el Obeid.—I

**By C. Leonard Woolley**

*This is the first of the author's articles on last season's work of the Joint Expedition of the British Museum and the University Museum, Philadelphia, on the excavations in Mesopotamia. The discoveries made are extremely important and throw quite a new light on conditions of life during the early dynasties.*

During last winter the Joint Expedition of the British Museum and of the University Museum, Philadelphia, was working upon two sites, the mounds of Ur and Tell el Obeid. The latter is a small mound first discovered and partially excavated by Dr. H. R. Hall in 1919; the results of his work have been described by him in the pages of Discovery (October, 1923). He found there a little building of plano-convex bricks, the oval-topped bricks which are characteristic of the early Sumerian period, and against one of its walls a hoard of very remarkable objects, statues and reliefs in stone and in copper, mosaic columns, wooden beams sheathed in copper, etc., which, though in bad condition, were of unique importance as illustrating the art of a hitherto unknown time. Clearly it was the duty of the Joint Expedition to carry on, as soon as was possible, the excavations so fruitfully begun by the British Museum, and accordingly this season, while the main body of the workmen were engaged on the heavy task of clearing the Ziggurat at Ur, a smaller gang, some sixty strong, resumed the excavations at Tell el Obeid which Dr. Hall had left in 1919. We started with high hopes, and were not disappointed, for the ruins proved extraordinarily rich in antiquities of first-class importance.

### Temple Site.

The extant remains are those of a platform whereon originally stood a small temple, now totally destroyed. The platform is approximately a rectangle thirty metres long, having its angles orientated to the points of the compass: from the S.W. side there runs out a square projection, a subsidiary platform containing a flight of stone steps; from the centre of the S.E. side there runs forward a long and narrow ramp, which supported a stairway built of massive blocks of stone; from the centre of the N.W. side projects a sort of buttress, its outer face steeply inclined, which supported a drain carrying the water off from the platform top. The platform itself was solid, the core of crude brick, the containing wall of burnt brick up to a height of 2.35 m., and above that of crude brick probably once whitewashed; the wall-face was relieved by a succession of shallow buttresses and recesses which stopped at about half a metre above ground-level, and were presumably finished off at the top also with a band of flush brickwork, so as to give to the whole wall that panelled effect which we associate with Sumerian architecture. The actual height of the ruined platform was 3.15 m.; calculations based on the two stairways show that it cannot have been more than six metres high originally, and an estimate of 4.50 m. would probably be nearer to the truth.

Of the building that stood on this platform not a single brick remained. It had been violently overthrown, and after its destruction the site had remained desolate until another king had used the ruin-heap as the foundation for a new terraced building of much greater extent; over the broken walls he had laid down a pavement of crude brick some two metres thick, and above this had built a new temple. This in its turn had perished, and later had been replaced by yet another, on the scattered bricks of which were stamped the name and titles of Dungi, the second king of the third dynasty of Ur, who reigned about 2250 B.C.; it was the discovery of such bricks that made Dr. Hall attribute to the original temple a date far back in the early days of the Sumerian occupation of the Euphrates valley.

### Oldest Document in the World.

Both the later structures were too much ruined to afford anything of interest apart from dating evidence, and it is only with the oldest of the three buildings on the site that this report is concerned; luckily, we can fix its date on evidence more satisfactory than mere calculation back from Dungi's period. Thrown out from the ruined wall was found the foundation stone of the original temple, a small marble tablet bearing an inscription which states that A-an-ni-pad-da, King of Ur, son of Mes-an-ni-pad-da, King of Ur, built this temple in honour of Nin-Khursag; the king's name is new to us, but his father's is given in the Sumerian king-lists as that of the founder of the first dynasty of Ur, the third dynasty of kings to bear rule over Mesopotamia after the Flood. The actual

INLAID FRIEZE OF WHITE LIMESTONE AND BLACK PASTE BACK-

date of the king is not so easy to fix, for the uncertainty whether the several dynasties were really consecutive or occasionally overlapped as rival kings disputed the claim to the suzerainty of the whole land, makes it impossible to trust to a simple dead-reckoning by lengths of reigns back from a known date; Professor Langdon would give 4000 B.C. as the lowest limit for Mes-an-ni-pad-da's reign; Mr. Gadd, who was with me in the field, is inclined, chiefly on epigraphic grounds, to bring this date down by several hundred years to the latter half of the fourth millennium; but, in any case, the little tablet carries back the history of Mesopotamia by many centuries, proves the authenticity of kings whom many modern writers had regarded as mythical, and is itself the oldest document in the world to which an authorship and an approximate date can be assigned.

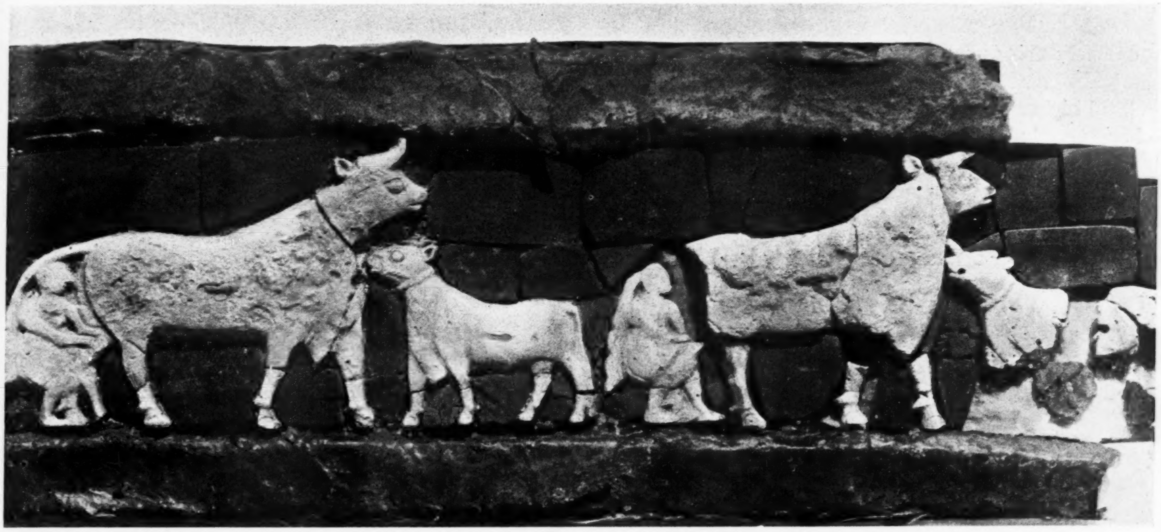
### Columns and Beams.

All the objects found in the ruins lay against its S.E. face, on either side of the main staircase; those to the east of the stairs were found by Dr. Hall, those to the west of them by the Joint Expedition last season; nearly all were the remains of mural decoration fallen, with the walls to which they belonged, from the temple that once crowned the platform. By a very careful study of their position in relation to the platform wall and to each other, and of the lines of fall traceable in the debris that covered them, it was possible to recover, at any rate in its broad outlines, the architecture of the vanished building, and to attribute to their original places the *disjecta membra* of its decoration.

On both sides of the staircase there were found many fragments, and even entire beams, of palm-wood overlaid with copper sheathing; some, comparatively slender, seemed to have been roofing-beams, others were certainly columns. With these were columns of a different sort, palm-trunks thickly coated with bitumen to which had been applied a mosaic of squares and triangles in bituminous paste, red sandstone and mother-o'-pearl, each tessera fixed by a loop of copper wire through the back of it into the bitumen bedding behind. We found two such columns complete, each 2.30 m. long, and remains of others. It became pretty certain that these columns and roofing timbers had belonged to a porch and doorway at the top of the staircase, and to this too we can assign the copper lions and the great "Imgig" relief discovered by Dr. Hall and described by him in his article. Practically all the other objects found last season came from the S.E. façade of the temple, which occupied only the south corner of the platform, having an open courtyard along its N.E. and N.W. sides, and it was only the S.E. façade that was very richly decorated.

### Bull Statues.

In a heap together we discovered the remains of four statues of bulls, worked in the round; they were made of thin sheets of copper hammered over a wooden core and fastened with copper bolts; two of them were too damaged to be removed, but two have been brought back to London and permit of restoration. They stand 0.60 m. high; the animals are represented as walking along with their heads turned outwards over the shoulder, and the style is remarkably realistic



GROUND, SHOWING COWS BEING MILKED AND BUTTER BEING STRAINED.

They seem to have stood in a row along a ledge running at the foot of the temple wall. Associated with them, probably arranged along a lower step, were artificial flowers, of which great quantities were found; these have the stem and calyx made in clay, in one piece, while the petals and corona are of red sandstone, white limestone and black bituminous paste, four white petals and two red and two black being set crosswise to form the blossom. It was at first supposed that they were wall-rosettes, the long cone-shaped stem being inserted in the brickwork and the flower-top flush with the wall, like cones and rosettes found on other sites; but there is strong evidence against this, and it appears certain that the flowers stood upright on their stems, held in position by wires that passed through and round the stems; and that they stood along a lower ledge so that the copper bulls appeared to be walking in a flowery meadow.

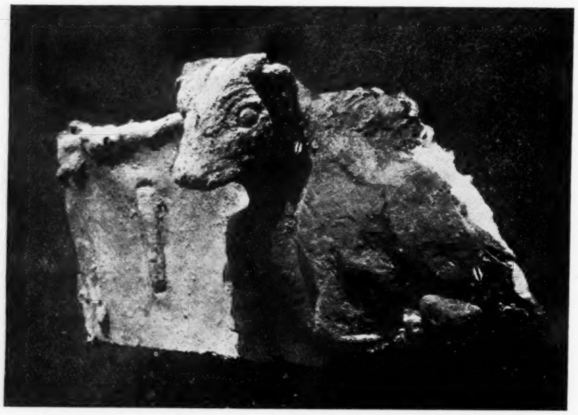
### Pastoral Frieze.

Higher up the face of the temple wall ran a frieze of copper, whereon in relief were represented heifers lying down but almost in the act to rise; the bodies were hammered up from thin plates of metal over a wooden core, and the heads were cast separately and attached; the work is astonishing alike for its naturalistic treatment of the subject and for the technical skill in execution. The frieze is 0.22 m. high, each animal about 0.60 m. long; between the animals are seen the copper holdfasts which passed through the wooden background and were secured in the brickwork by pegs driven through their rings; twelve figures were found more or less complete.

Higher up again was a frieze of a very different character. Attached to a wooden plank covered with bitumen and framed between copper borders was a mosaic with figures of limestone or of shell against a background of pieces in bituminous paste. Large fragments of this were recovered intact, in spite of the complete decay of the wood and bitumen background; in most of these the figures were of shell, the body and limbs cut out separately and fitted together, carved with such art that what at first sight appears to be merely a silhouette is found on closer inspection to be the most delicate relief; but in the most important fragment the material used is limestone and the work less fine—probably because here paint was employed over the whole surface. This scene gives us, on the left, men milking cows; the men squat awkwardly beneath the cows' tails, milking into tall narrow vases; the muzzled calves stand in front; in the centre is a reed-built byre from the door of which are coming out two heifers; on the right are four men, one ladling out some liquid from a big pot, one pouring a liquid from a small vase through a strainer held by the third man into a bowl or tub resting on the ground, one standing ready with the great store-jar that is to contain the strained liquor (which, from the character of the neighbouring scene, we can assume to be clarified butter). It is a *genre* scene of pastoral life in the fourth millennium B.C., such as we could never have hoped to obtain by excavation. In both subject and treatment it contrasts strongly with a plaque which none the less formed part of the same frieze, a limestone carving showing a human-

headed bull on whose back is a lion-headed eagle ; obviously this is some mythological scene, though we may not be able to interpret its meaning.

Still higher up the façade was a third frieze of similar character, but in this case the subject is simpler—a row of birds in white limestone (once coloured ?) against a black ground. Very little of this frieze was found, as, falling from a greater height, it was



HEAD AND SHOULDERS OF ONE OF THE COPPER RELIEFS OF BULLS, FROM THE TEMPLE FRIEZE.

more broken up and its fragments scattered farther afield and therefore less protected by the piles of débris from the walls.

**Art of the Period.**

It is indeed a happy chance that preserved so many objects from the temple, and preserved them in such conditions as to enable us to get a fair idea of the original appearance of the oldest dated building that has yet come to light ; and in themselves these objects are of prime importance for the entirely new conception that they give of the art of this remote period. Fortunately, too, they do not stand alone. Apart from the architectural remains already described, the ruins produced a number of other objects, the discovery of which alone would have made our season a success. Chief of these is a gold bead of oval scaraboid shape on the back of which is inscribed the name of A-an-ni-pad-da, King of Ur, the temple's founder ; probably it formed part of the foundation deposit (it was lying loose in the debris) and certainly it is the most ancient piece of royal jewellery known. A broken stone vase also bears a complete inscription with the same king's name, and records the dedication to the goddess Nin-Khursag, by one Ur-Nana, of a well ; it is tempting to associate with this a limestone well-head carved with scenes of worship whose fragments we found in front of the stairway ; it is strangely primitive in comparison with the carvings of the temple proper, yet it must be contemporary with them.

Not less interesting in their way than the Nin-Khursag shrine were the graves which we discovered in a low mound close by. That the oldest of them were contemporary with the first dynasty was shown by the fact that some of the clay vases they contained were identical with those represented on the "milking-scene" relief ; others were undoubtedly later, coeval with the second building that occupied the temple site ; none were so late as the third dynasty of Ur. There were various types of burial. In most cases the body was laid on its side in the crouched or "embryonic" position in a very shallow open grave ; no trace of coffin or of mat wrapping could be detected. In a few cases the body was extended on its back in an open grave ; in two the grave was brick-lined. In one part of the cemetery there were regular larnakes or bath-shaped coffins of baked clay.

The pottery in the graves showed a very wide range of forms, but decoration was confined to an occasional rope-moulding or simple incised ornament ; there was no painting. Copper tools and weapons were rare, but copper bowls not uncommon ; of stone vessels there were many, nearly always of bowl form, with a considerable variety of material. Stone

SOUTH-EAST FRONT OF THE TEMPLE PLATFORM, TELL EL 'OBEID.

implements were rare in the graves themselves, though there were plenty in the surrounding soil ; occasionally there were imitations in clay of both stone and copper tools. Personal adornment was represented by beads, mostly of carnelian, lapis lazuli and crystal, with pendants in the same materials, and by copper pins, one of which was conspicuous in having a head of lapis lazuli and gold ; red haematitic paste was found, pre-

sumably rouge, and shell palettes containing a green malachite paste, probably for painting the eyes, recalled the similar custom in prehistoric Egypt. Spindle-whorls, loom-weights, fish-hooks, grinding-stones illustrated the domestic life of the time. One complete skeleton and a number of skulls were brought back, and the study of these should throw much light on the vexed subject of the racial character of the early inhabitants of Mesopotamia.

### Earlier Graves.

When the first dynasty people started to dig their graves in the mound at Tell el Obeid, it already contained numerous interments and some hut remains of a still earlier folk, so much earlier indeed that their memory was gone and any sanctity that might have attached itself to their relics had evaporated; the

A LARNAX GRAVE IN THE CEMETERY AT TELL EL OBEID.

new gravediggers when they lit upon an older tomb broke and scattered its contents without piety or regard. Only one grave dating from the earlier period was found by us more or less intact, but everywhere we came upon evidence of the destruction of the rest. The main contents of these had been painted hand-made pots, flint implements and rock-crystal beads; fragments of such pottery were first reported from Abu Shahrein by Mr. Campbell Thompson, and later were found at Ur and at Tell el Obeid by Dr. Hall; now for the first time we have vessels either complete or so far preserved that their form, as well as their decoration, can be restored, and we find that in form as well as in decoration they recall the early wares of Sousa and Moussian. Here we are beyond all history and dating; we can only be sure that these painted vases afford the earliest record we yet possess of human activities in the lower Euphrates valley.

The objects found in the course of the excavations will be divided between the Iraq Government, the British Museum and the University Museum, Philadelphia; at present all the more important of them are collected together for a temporary exhibition at the British Museum, and those who are interested in the early history of mankind have the opportunity of seeing, before its dispersal, the entire series of sculptures, reliefs, etc., which revolutionise our ideas of art development. I should like to add that the British Museum's share in the work of excavation at Tell el Obeid was made possible by a generous gift from Mr. A. L. Rickett and to congratulate him on the really magnificent results of that gift.

## FRENCH SLEEPING SICKNESS CURE.

The Bayer 205, which was kept as a secret remedy by the Germans, who hoped by keeping the secret to acquire dominion over large portions of Africa which are scourged by the disease, has now a rival.

M. Fourneau, working to find a trypanosome slayer, has found a "symmetrical urea" of a meta-animoacid—sodium trisulphonate. To this drug he has given the name 309. He claims that it is if not identical with Bayer 205 it has at least the same effects. He is giving the formula and the method of preparation to the world.

## BOOKS RECEIVED.

*The Biology of Flowering Plants.* Macgregor Skene, D.Sc. (Sidgwick & Jackson Ltd. 16*s.* net).

*Annals of Archaeology and Anthropology.* (University Press, Liverpool. 6*s.* net).

*The Greatest Story in the World.* Horace G. Hutchinson. (John Murray. 3*s.* 6*d.*).

*General Science.* R. Acton, M.A. (John Murray. 3*s.* 6*d.*).

*Biology and Human Welfare.* James Peabody, A.M., and Arthur Ellsworth Hunt, Ph.D. (Macmillan & Co. 8*s.* net).

*The Vacuum.* J. A. Cochrane, B.Sc. (G. Bell & Sons Ltd. 1*s.* 6*d.* net).

*How to Avert Cancer.* H. Reinheimer. (Grevett & Co. Ltd. 2*s.* net).

*The Doctor's Oath.* W. H. S. Jones, M.A. (Cambridge University Press. 7*s.* 6*d.* net).

*Athens: Its History and Coinage.* C. T. Seltman, B.A. (Cambridge University Press. 42*s.* net).

*Across the Sahara by Motor-car.* Georges Marie Haardt and Louis Andouin-Dubreuil. (T. Fisher Unwin Ltd. 12*s.* 6*d* net).

*The Theory of Relativity.* Archibald Henderson, Allan Wilson Hobbs and John Wayne Lasley, Jr. (Humphrey Milford, Oxford University Press. 11*s.* 6*d.* net).

*Introduction to Modern Philosophy.* C. E. M. Joad. (Humphrey Milford. Oxford University Press. 2*s.* 6*d.* net).

*The Great Pyramid: Its Divine Message.* D. Davidson, M.C. M.Inst.Struc.E. and H. Aldersmith, M.B. (Lond.), F.R.G.S (Williams & Norgate Ltd. 25*s.* net).

# Measuring the Universe.

**By A. Vibert Douglas,**

*Prof. Astro Physics, McGill University.*

*This article shows how astronomers are actually making use of some of those brain-racking mathematical conceptions which we associate with the Einstein Theory to correct or amplify existing theories. The result of Dr. Silberstein's Doppler formula successes enables us to gain a mathematical idea of the volume of the Universe as about one thousand million times the size of the galaxy of stars around us. His discovery is of the greatest importance.*

The Universe in which we live is not the simple thing it was thought to be a generation ago, and which we to-day would still be thinking it, had not men of science begun to measure the velocity of light signals and the motions of the planets and the stars with a precision undreamed of half a century ago. They it is who have shown that the geometry of Euclid which is so useful and so true in all terrestrial measurements, and for this reason making such a strong appeal to the common-sense of everyday life, is not equally satisfactory when measuring the positions and distances of the stars, indeed, is quite incapable of representing the facts. They it is who have shown that the laws of Nature enunciated by Sir Isaac Newton—laws sublime in their simplicity—laws that fit all the facts of our everyday terrestrial experiences—are not absolutely true to the last refinement of scientific precision when phenomena of stellar magnitude are under observation.

### Four-dimensional Space-time.

Thus it was the stern facts of Nature and not the whimsicality of a metaphysical mind that led Einstein to postulate for the framework of the Universe a four-dimensional space-time which conforms to the principles of what is known to the mathematician as Elliptical Geometry. Man is finite and three-dimensional, but when he thinks mathematically in quite general terms he is not thus hampered, but can carry the logic of analogy into four, five or *n* dimensions, though of course his ability to visualize his results ceases the moment he passes beyond three dimensions. It is only and solely because the observed facts of Nature do agree with results of calculations based upon these four-dimensional space-time equations, that the theory of relativity has not merely survived, but has firmly established itself in the minds of the majority of scientific investigators.

Einstein laid the foundation stone of this modern conception of space-time, and others are working with him in an effort to erect on this foundation a super-structure which will adequately represent the Universe as the facts of Nature reveal it.

Amongst these master builders is de Sitter, who proposed a modification of the Einstein cosmological equation in order to avoid an outstanding difficulty which it involved. Thus the de Sitter space-time equation became the basis of investigations of the Radial Velocities of stars. This line-of-sight velocity is measured by the astronomers by means of the Doppler effect, that is to say, by measuring the displacement of a line in the stellar spectral photograph relative to the position of that line in the spectrum of a similar source of light on the earth (Fig. 1). Both de Sitter and Weyl showed theoretically that the greater

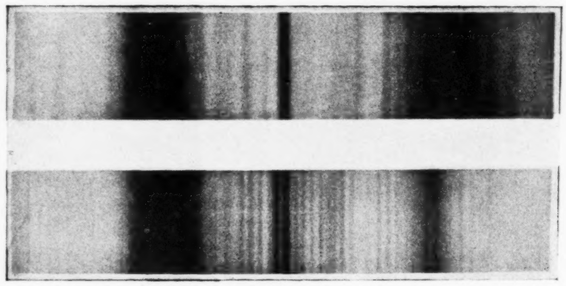


Fig. 1

Two spectral photographs of a double star, $\beta$ Aurigae, taken when the component stars are in the line of sight and when they are at the extremities of their revolutionary orbits at right angles to the line of sight. The doubling of the lines in the second spectrum illustrates the Doppler displacement towards the red in the case of the receding component and towards the violet in the case of the approaching component. The shift of the single lines relative to their known standard positions gives a measure of the radial velocity of the double star considered as a unit.

the distance of the star from the observer the greater would be the shift of the spectral lines, but in doing this each found it necessary to introduce a limitation into the reasoning, the former assuming that the relative position of the star to the observer did not vary, the latter assuming that all the stars are diverging into the future from a common point of origin. Hence both these theories allow only for a shift of the spectral lines towards the red or longer wave-length end of the spectrum, which would mean that all the celestial bodies were receding from the Solar system. This, however, is not borne out by observation—many of the stars and about ten per cent. of the spiral nebulæ and a large proportion of the globular clusters being

known to be approaching it. Thus, applying the one crucial test to these two theories, namely—Do they fit the facts of Nature ?—they are found wanting.

When lecturing recently at McGill University, Montreal, Dr. L. Silberstein announced the result of his latest investigations along this same line.* Making use of de Sitter's space-time theory without limiting it in any way, Silberstein develops a new formula for the complete Doppler displacement, by which he shows that this spectral shift may be either toward the red or toward the violet and is due to two causes. The first is an individual characteristic of the star and is the radial velocity which it would have when nearest to the observer whether that time of closest approach took place in the past or would take place in the future.

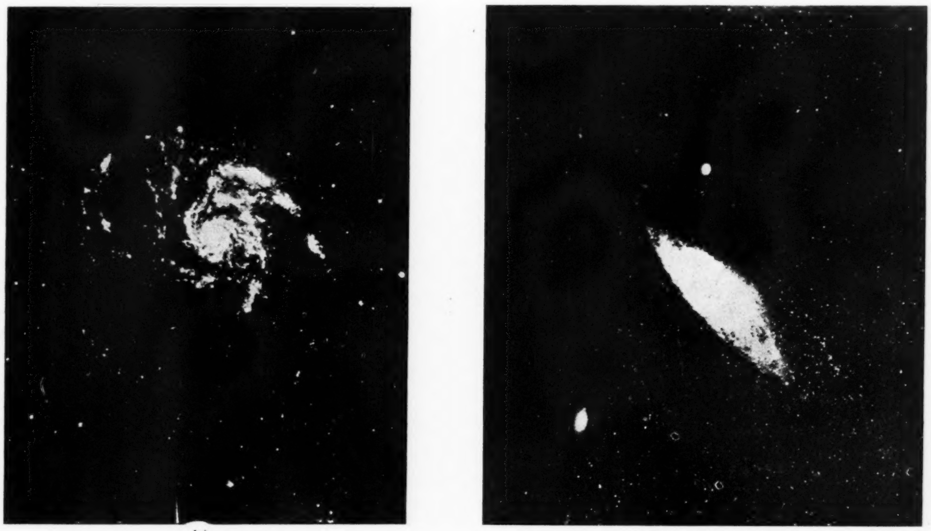
## Shift of the Lines.

The second cause of shift is due to the four-dimensional nature of space-time and is measured by the ratio of the distance of the star from the observer to " the curvature invariant " of space-time. This " curvature invariant " or " radius of curvature " of the three-dimensional section of space-time is essentially a geometrical property of the Universe just as the radius of a sphere is a property of that Euclidean type of space, but while our minds can see or conceive the latter, they cannot visualize the former though its mathematical significance offers no difficulty. The use of the term " curvature " is unfortunate and misleading. It arose by carrying the phraseology of three dimensions to the analagous mathematical idea in four dimensions, for which of course there was no word since the conception can exist in the human mind only as a mathematical expression. Let us forget the word " curvature " and call this intrinsic property of space by the conventional symbol, R.

## Limits for R.

Now the question which presents itself to the inquirer is this—Can R be measured in terms of anything we know and understand ? In 1917 de Sitter showed that it was possible to make several estimates of the magnitude of R utilizing what scanty data was then available for the distances of stars and clusters, the angular diameters of the clusters, the volume of our galaxy and its star density, the spectral shift for distant stars, and the absorption of light in space, data due to the investigations of astronomers like Kapteyn, Shapley and others. From these he deduced upper and lower limits for R, namely $10^{13}$ and $10^{10}$ astronomical units (this fundamental unit is the distance from the Earth to the Sun).

But a great deal of confidence could not be placed in these figures, first because they were partly based on theories shown to be inadequate, secondly



(a) (b)

Fig. 2

Typical Spiral Nebulae about whose nature there is so much speculation. They are found in large numbers in regions away from the Milky Way. They have very high recessional velocities, their spectra resemble that of F-type stars rather than of gaseous objects, but their distances are unknown. (b) is the Andromeda nebula, and, making use of his determination of R, Silberstein estimates its distance as $6 \times 10$[illegible] astronomical units or approximately 100,000 light years.

* Silberstein has since published an outline of this investigation in *Nature*, 8th March, 1924.

because there was not sufficient observational data upon which to base the calculations, and thirdly because the agreement between the various estimates was not good, though indeed the remarkable thing is that there was any appearance of agreement at all.

It is therefore of tremendous interest and importance to hear that Silberstein has succeeded in evaluating R with a precision and weight truly remarkable, and it is almost equally remarkable that his mean figure lies well within the limits suggested six years ago by de Sitter.

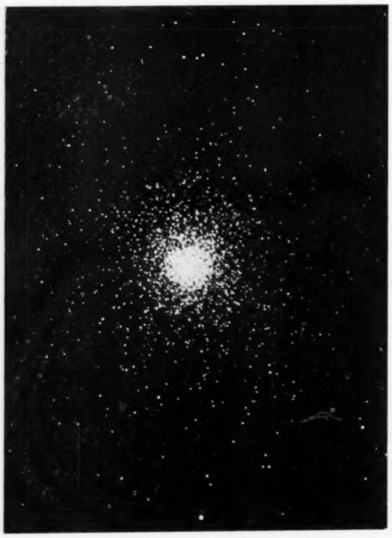


FIG. 3.
Globular Cluster in the constellation of Hercules. Typical of some ninety globular clusters of which, however, the distance and radial velocity are only known for eight. Upon seven of these clusters, whose average distance is 60,000 light years and whose average radial velocity whether approaching or retreating is 205 km./sec., Silberstein calculated his value of the radius of curvature of space-time.

**What it Means.**

In Silberstein's Doppler formula, above explained, the second term is shown to dominate the result for the remote stars which are near the boundary of our galaxy, and even more so for the spiral nebulæ which are themselves possibly small galaxies of stars lying far out beyond the fringes of our galaxy (Fig. 2). For these distant celestial objects the formula reduces to a simple law: Doppler displacement multiplied by parallax (an angular measurement of the distance from the Solar system) is always constant and this constant has a physical interpretation as being the parallax of the most remote object whose light would ever reach the Earth, namely, the inverse of R in astronomical units.

Making use of the measurements of distances and Doppler displacements obtained by Shapley for seven globular clusters (Fig. 3), both receding and approaching, Silberstein has calculated the value of R and obtains the mean result $6.00 \times 10^{12}$ astronomical units. Including also the data for the Greater and Lesser Magellanic Clouds (Fig. 4), the mean value of R comes out to be $6.07 \times 10^{12}$ astronomical units.

Though four-dimensional space-time is of infinite extent, its three-dimensional space section, of which we perceive a small part, is mathematically-speaking finite in its volume, and using Silberstein's value of R, that volume would be something of the order of one thousand million times the size of the galaxy of stars around us.

FIG. 4.
The Greater Magellanic Cloud, seen from the Southern Hemisphere, near the Milky Way, has a radial velocity of 270 km./sec. and is distant 66,000 light years.

The mind is staggered by these figures and baffled at its own inability to visualize the ideas upon which these measurements rest, but surely the centre of our amazement may well be the power of the human mind itself—the inspired courage and profound insight of those minds which, though essentially limited to a three-dimensional perception of reality, can yet burst the bonds of this limitation in their reasoning, and, asking Nature herself to be their guide, measure the space-map of the space-time universe in which we dwell.

# The Botany of Our Coasts.

**By S. M. Wadham**
(*Botany School, Cambridge*).

*The coastline presents particular features of vegetation which occur nowhere else. To the townsman and the inland dweller coastline vegetation is a mystery. This article explains some of its most important features.*

THE glory of the British coastline is its diversity. In most parts of our shores rocky headland follows sheltered bay, and is in its turn succeeded by marshy estuary with shingle banks and sand dunes. Botanically these areas all agree in being of interest, though the nature of that interest changes with each type of scenery.

### The Break where Land joins Sea.

One feature there is which is common to all, and that is the break in the vegetation where shore joins land. This break is almost complete. The marine plants of the sea do not survive on the land, and the land plants fail to live in the sea. Generally speaking, the marines are algae, which do not form seeds. Here and there, however, are exceptions e.g., the Cordgrass in Southampton Water and the plants of salt marshes, some of which can stand frequent immersion. On the other hand, some of the marine algae do occasionally manage to live in mud, for instance certain Wracks on east-coast flats, but in many ways these seem to be degenerate—they do not produce their customary reproductive cells and live and spread by vegetative growth alone. Even where freshwater streams join the sea the marine algae do not grow far up their beds; one or two species live on in brackish water, but it seems at first sight as if the conditions of life in sea water are generally essential to the one and a hopeless barrier to the other. Further reflection, however, calls to mind the luxuriance of Cordgrass in sheltered areas of the muddy shore and the presence of forests of Mangrove in salt water in other parts of the globe, and suggests that other causes are at work. An examination of some of the algae at once reveals the fact that whatever their colour or shape or texture, they are invariably fixed firmly to some rock or breakwater; further, their organ of fixation is not a root as in a land plant, but a discord or branched holdfast. The solid rock offers no hold to a root and the waves remove all smaller particles which might go to make a soil in fissures and holes; the bare shifting sand supports no vegetation at all; any seedling of a land plant which germinated here would be swept away by the next high tide before its young radicle could obtain any grip. Possibly this structural difference is enough to account for the sharp demarcation of the vegetational regions of the shore.

FIG. 1.—MARRAM.
A bird's nest can be seen between the two tufts in the foreground.

### Plant Life on Shingle and Sandbanks.

On many stretches of our coasts deposition of material by the sea is in progress; banks of shingle and sand accumulate one after another. Here we find many plants which do not occur in inland regions. Past generations of botanists said these plants liked salt, and called them "halophytes." Moderns would prefer to suggest that the chemical and physical mechanisms of the sea plants can operate when salt is present in quantity in the soil—an abnormal state of affairs for most land plants.

### Water Relations of Shingle Plants.

The sand or shingle bank presents other obstacles to plant life in addition to the amount of salt in it. Every land plant is continually taking up water through its roots. This water passes up the stem and into the tissues of the leaves. The inside of every leaf is honeycombed with air spaces, and this system of air spaces connects with the outside air by means

of small pores (stomata). The water evaporates into the internal atmosphere of the leaf and is continually passing out of the pores while relatively dry air from the outside is continually passing in. In most land plants the stomata are the only connecting channels between the inside of the leaf and the outer air, the whole surface of the leaf and stem being covered by a continuous waxy coat (cuticle) which is but slightly permeable to water. For the healthy existence of a plant a reasonable balance must be maintained between the amount of water taken up by the root and the amount evaporated and lost by diffusion from the leaf. If this balance is seriously upset the plant loses more water than it can replace, the leaves become limp and the living material of their cells is damaged. If this state of affairs continues for long the plant's normal development cannot continue and death occurs.

Any factor which tends to diminish the amount of water absorbed by the root or the amount lost by the aerial parts will be a menace to the life of the plant. Now water passes to the roots over the surfaces of the particles in the soil. A soil largely composed of minute particles (e.g., a clay), will hold and pass up much more water than will one in which most of the particles are large, e.g., a gravel or sand. A shingle bank consisting of fairly large stones is possibly the most difficult type of substratum on which a flowering plant can exist. A new bank of shingle alone is almost uncolonisable, but where sand is mixed with the stones a sparse vegetation appears. As time passes an old shingle bank receives continual additions in the form of dust and sand particles, which are blown on to it and fill in the crevices between the stones; thus gradually the habitat becomes a more suitable one for plant growth.

Characteristic plants of these areas are the Yellow Horned Poppy, the Sea Pea, the Sea Campion, Sea Purslane, Stonecrop and Seablite. Most of these have rather thick leaves and a prostrate habit; the former character is due to the development of watery tissue which possibly functions as a reserve in particularly dry spells. Other plants typical of dry soils appear as the age of the bank increases and with it the amount of finer material present. The Elder, Viper's Bugloss with its one-sided spikes of purple flowers, and Herb Robert are among the commoner of these. These plants have very long roots which penetrate into the moister layers of the soil below; their upper portions are also developed in an abnormal fashion; the leaves are thick structures offering a relatively small surface to the sun, the waterproof cuticle is thick, the stomata are small and few. All these features lessen the amount of water which is lost to the air by the upper parts.

The sandy areas are less unfriendly to plant growth in that their soil does retain a slightly larger amount of water than does shingle, but they are very dry places. In addition, at many points on the coast, every on-shore wind blows a steady stream of sand particles towards the shore; these pile up and in time form new dunes around the base of any obstacle which catches them. These little dunes may grow inches in a day and would smother many plants so that only those members of the vegetable world which have the power of growing up with the sand, and forming new underground systems of roots and stems at higher levels, can survive under these conditions. The plants themselves fix the dunes. A few minutes' spadework on a dune will soon reveal a dense mass of underground stems and roots at different levels in the soil.

**The Colonisation of the Sandy Shore.**

In an area of advancing sand dunes it is an interesting study to start from the shore and walk inland, noticing the gradual change in the plants and in the character of the vegetation. First come the early colonists, usually Agropyrum junceum, a small wiry grass with flowers similarly arranged to those of wheat. The Marram Grass with long, very tough leaves, which on a dry day are rolled into pointed cords but after a shower unroll and become relatively broad (Fig. 1). The Marram is the grass about which most sand collects; it is essentially a "dune fixer," and has been employed as such with conspicuous success in various places, notably on the French coast south of Bordeaux. These two are the chief plants on the seaward slope and crestline of the first dune range. On the landward side, where the deposition of the soil is proceeding less rapidly, Sea Holly and the Sea Lyme Grass with its silvery pointed leaves appear in patches. Scattered about on the early dunes are occasional plants of Sea Kale—the wild type from which the vegetable has been produced—and Sea Rocket; these both have polished succulent leaves and small mauve flowers. Another frequent plant all over these dunes is Sea Purslane whose thick pointed leaves are crowded in four vertical rows, its flowers are small but its bright red seeds are a common feature of the autumn.

Over the crest, on the landward slope, the prospect will depend on the amount of sand which is not caught by the first dune. If little is blown over many new plants appear, but if the supply is large there will be a trough followed by a second dune line. Several crests may occur in this way, but eventually one will be encountered over which little sand crosses, and here the carpet of vegetation will gradually become

a continuous one. The new arrivals are usually Stork's Bill, Rest Harrow, Stonecrop, Sand Sedge, Ragwort and various grasses, mosses and lichens. In different parts of the coast different plants appear in abundance; for example, in the hollows of the dunes of the Lancashire coast the Creeping Willow, a sprawling plant with exceedingly long roots, and the Winter Green are abundant. On the Norfolk coast a bushy shrub, the Sea Buckthorn, is becoming abundant. This last plant is a migrant from the coasts of Belgium; the undersurfaces of its leaves are covered with curious scaly hairs which can easily be seen with a hand lens. In other places Pines have been planted and grow successfully.

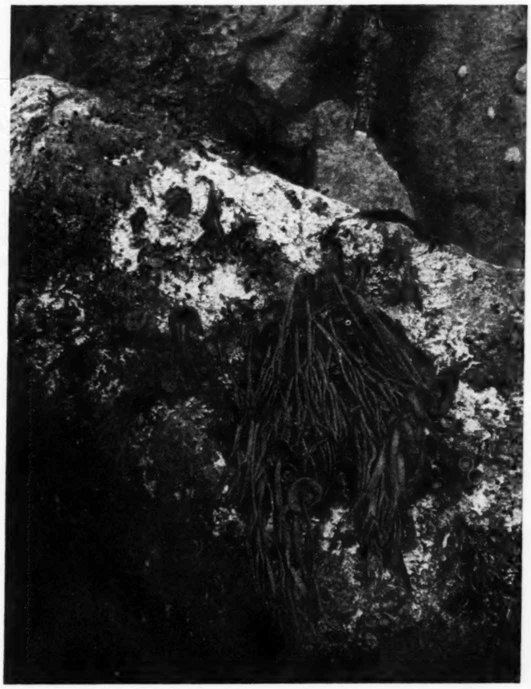


Fig. 2.—HIMANTHALIA.

In these areas in which the flora is relatively dense the Marram tufts become less frequent, their leaves are brownish at their tips, and the whole plant has an unhealthy appearance. Farther on, areas occur in which it is entirely absent. The reasons for its gradual decadence are uncertain; it is easy to speculate on such matters, but only detailed work on the physiology of the plant itself will reveal the true cause.

Behind the dunes the land is usually put to some practical use. In the neighbourhood of towns it is the happy hunting-ground of the golfer, for whom the irregular crests of old dunes form natural bunkers of distressing efficiency; the close short turf where the Marram has been eradicated and smaller grasses predominate makes a good fairway. Care is, however, required, as the habitat is not conducive of rapid growth; a neglected "divot" may leave a hole which in the strong shore winds may become the seat of an eddy, this will remove the sand from below the adjacent turf and cause the formation of a "blow-out."

Rabbits are frequently present in large numbers where no effort is made to keep them in check; they may become a scourge to the vegetation, and eat down the flowering plants to such an extent that lichens become the dominant feature in the vegetation; Peltigera, with its flattish olive-green body and Cladonia, an erect grey-green much branched type, are two of the commoner forms. If rabbits are kept in check a poor dry pasture land results; the possibility of improvement depends largely on the climatic conditions. If the area is one of high rainfall, plant remains will accumulate and form humus which will gradually enrich the soil, leading to the appearance of more valuable pasture grasses; if, on the other hand, the area is one in the drier eastern counties, the soil will improve more slowly and may only bear a poor heath vegetation.

**Salt Marshes.**

In some places where freshwater streams debouch upon the sea, flat areas subject to periodical inundations become cut off by lines of dunes or shingle banks. On such areas mud and silt accumulate and a salt marsh vegetation appears. A typical salt marsh presents a flat expanse of sticky mud, intersected by innumerable streams and dotted over with shallow pools. There are usually one or more main streams, and the areas around these remain wet for longer periods than does the remainder of the marsh; their flora is sliegthly different to that of the drier portions of the area. The chief plants here are the Seablite, a straggling low bush with mealy leaves, small yellowish flowers and inordinately tough stems; *Glyceria maritima,* a straggling member of the Grass family, which plays a useful part in the botanical economy of the region by binding together the soil; the Sea Aster with stems about ten inches high bearing fleshy smooth leaves and, in September, mauve and yellow flower heads. The Marsh Samphires which also occur here are most fascinating plants which well deserve closer inspection. At first sight the plant appears to consist of a number of smooth swollen segments, arranged in occasionally branching rows; the colour may be anything from green to brownish-

yellow, according to the species. The whole plant is juicy, and when young is often gathered and eaten as a vegetable. The flowers occur in groups of three at the stem joints, they are very inconspicuous and have no bright colours, but in August a yellow stamen or two hanging out may reveal their true nature. If, when lying on the ground looking at a clump of these plants the fancy is allowed to wander, it is possible to imagine that the observer is confronted by a Cactus grove of Liliputian dimensions. There are similarities between these salt marsh plants and those of desert areas; the squashy tissues, due to large cells filled with watery sap, the smooth surfaces of the plant organs, and the absence of definite leaves are points of resemblance reflecting the fact that in both cases the internal economy of the plants is abnormal—probably owing to lack of water in the one case and its salinity in the other. The drier parts of the marsh nearer the edge are often covered with the Sea Thrift and Sea Lavender (*Statice*), both of which are frequently cultivated in gardens and greenhouses. When these are in flower in July and August the whole area assumes a pink or purple hue of singular beauty.

When, in the passing of time, an area of this kind gradually dries, and the soil loses its salinity, valuable grasses often appear and with them clumps of Rushes; the natural sequence of events is now usually disturbed. The grass makes excellent pasture and the agriculturist encloses it as grazing land, or after draining it may put it under the plough.

**The Rocky Shore.**

On rocky stretches of coast where the sea is ever grinding at the land and tearing it away, the cliffs rise abruptly from the tidal zones, and the plants of the land are mostly those typical of the soil on which they grow. The cliffs themselves offer poor shelter for plants, but in occasional crannies the Sea Spleenwort fern may be found, and a few other species not members of a normal land flora. Near the high-water mark little grows except lichens, but within reach of the spray the first examples of the marine vegetation appear. They are marine algæ belonging to a group which takes its name from the predominant colour—which is brown. This group of plants is in interest second to none in the whole plant kingdom. Everywhere between the limits of high spring tides, and for some feet below the lowest spring tide, there is a mantle of these plants round every rocky area of our coast. A few minutes' observation in such a situation during a storm at once reveals the difficulties of plant life; the tremendous pull of the sea and the continuous change of direction of that pull, impress one with the fact that only a plant built on the stoutest lines could survive in such a place. Experimental observation with a spring balance confirms the deduction; specimens of Wrack will often fail to break under a direct pull of sixty pounds or more. In other directions also the habitat is an exacting one; the summer's sun beats down on the rocks with great intensity and the plants lie exposed to its full force, whenever the tide is down. They have no waxy covering like the land plants, as they take in water and gases over their entire surfaces; they do, however, develop large quantities of mucilage—often a trap for the unwary scrambler—and apparently this mucilage enables them to avoid desiccation. They form no seeds, but small cells which appear on certain areas of their bodies—in little pustular cavities near the tips of the fronds in the case of Wrack—are responsible for their propagation.

**Zones of Plants on the Rocks.**

There are several different kinds of these plants, and careful observation soon reveals the fact that each type has its own zone on the rocks (Fig. 4). At the high-water mark and just above appears *Pelvetia*, a small plant growing in tufty greenish-brown masses; each of its thongs has a furrow running down it and is devoid of the central longitudinal strand possessed by all the members of the Genus Fucus (the true "Wracks"). The plant's existence must be very precarious, as at neap tides in calm weather it is often untouched by water for days together. Three or four feet lower down the rocks appears *Fucus spiralis*, a Wrack with rather broad fronds and occasional bladders. A few feet farther *Ascophyllum nodosum* appears, to the exclusion of the preceding type; this form has long greenish thongs with occasional single air bladders and produces branches from its sides; this is a point of distinction from the Wracks, whose branching always begins at the tip of the frond in the region where growth occurs. A little lower is the Bladder Wrack, usually distinguished by the presence of bladders and the shape of its frond. Lower down again is the Saw-edged Wrack, bladderless and tough. Below this is a curious plant, Himanthalia (Fig. 2), the thongs of which are like a branched bootlace springing from a leathery disc-like base; the disc grows first and takes the form of a top, from the centre emerge the thongs which flourish during the summer; in the winter the thongs are torn off, but the discs remain and produce fresh thongs in the following year. At the low-water mark are the "Kelps" (Fig. 3); two forms are common—one with a stout stipe some two or three feet in length and a broad blade torn into numerous ribbon-like segments—the other with a short stipe and

longish, crinkled blade. Each autumn the reproductive cells are produced in the blade of the Kelp, the areas on which they are being formed being readily seen owing to their greater opacity. After discharge of their spores, the flattened portions of the plant are torn off by winter storms, but in the spring

FIG. 3.—IN THE KELP ZONE.
Note that each boulder, being a little higher, has a covering of Wrack.

a new blade grows from just above the stipe. For many years the fate of the reproductive cells was a mystery, but it has recently been shown that each develops into a very minute independent plant on which sexual cells are formed. These are of two kinds—small motile male cells and large stationary eggs. These fuse and a small kelp gradually develops from the fertilised egg.

## How to make a Collection.

Although the Wracks and Kelps are the plants which make most impression on the eye, there are many other smaller types growing among them and in the rock pools. These show greater diversity of form and structure. A close examination of them, especially if a hand lens is employed, reveals the fact that they are among the most beautiful things in the plant world. The small ones are easily collected, and can be preserved with their natural colours by a simple process. A good specimen of small size is collected and washed. It is then floated in a dish or soup plate of *fresh* water for a few hours, a sheet of stiffish paper is inserted below it and the branches are arranged symmetrically. Raising the paper gradually brings the specimen to the surface; it is now covered with a piece of "butter muslin," and the whole is placed between sheets of blotting-paper under a weighted board. After a day's pressing the blotting-paper is changed and the process is repeated until no more water leaves the specimen; the dry muslin will now peel off easily and the specimen remains adherent to the paper.

## Some of the Commoner Forms.

The diversity of these small plants is great; the majority of them belong to the red Algae, but green and brown forms are also present. The following "structural types" can usually be found:—

1. Encrusting Forms.—These grow on bare rock and are at first sight often mistaken for rock itself. They are smooth, or velvety, brown or red, and are most evident in very exposed spots where the Wracks are unable to maintain their position in abundance.

2. Calcareous Forms—common in pools.—These secrete quantities of calcium carbonate in their tissues and form miniature coral reefs. *Corallina*, one of the commonest, has a branched body which is jointed in the same way as the legs of a crab.

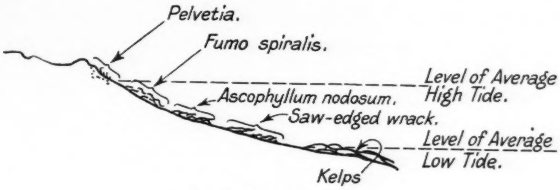



FIG 4.—PLANT-ZONES.

3. Thread-like Forms—which may consist of single strands of cells or of cells arranged in tubular or columnar manner.—These are very numerous; the commonest is probably the green *Enteromorpha intestinalis*, whose hollow tube is often mistaken for a simple ribbon. Abundant also are the tough green threads of *Chaetomorpha* and the brown *Ectocarpus*, while in some localities *Castagnea*, a thick copiously branched "brown," is abundant. Of "reds" there are many, the delicate and profusely branched *Polysiphonias* being the most abundant. Shrub-like *Chylocladias* and *Laurencias* are common, while *Furcellaria*, with a stiff body like a minute leafless bush, is frequently found.

4. Flattened types.—*Delesseria sanguinea*, with a crimson frond resembling a beech leaf, is one of the most beautiful objects of the seashore. The Sea Lettuce (*Ulva*), forms bright green sheets attached to rocks. *Punctaria* and *Phyllitis* are firmer brown types.

Research work on the problems of life of the seashore has only begun; it is an area which teems with problems, but unfortunately owing to the concentration of universities in inland towns and the lack of adequate facilities the workers are few.

# The Use of the Ultra-Microscope.

By D. C. Henry, M.A.

*The development of the ultra-microscope has added a new weapon to the armoury of scientific workers. Its optical construction and the principles of its use, though simple, are little known. By its use it is believed that many problems that have hitherto baffled workers will be brought appreciably nearer solution.*

THERE are three qualities of a microscope, each of them of importance for its scientific use, which are to a large extent independent of one another. These are the magnification, the resolution, and the power of making visible very small objects.

There is theoretically no limit to the magnification possible, though in practice it is limited by the complications involved in correcting for spherical and chromatic aberrations in objectives of high power.

It is quite otherwise with the resolution, or power of giving distinguishable images of neighbouring points of the object. The image of a point, even when produced by an optical system of absolute perfection, is a disc of finite size. It is found that two overlapping discs can only be distinguished as double when their centres are separated by a distance at least equal to their radius. The distance apart of two points in the object which give rise to image-discs in this position is therefore the limit of resolution of the microscope, and no details of shape or structure on a finer scale than this are distinguishable. The limit of resolution of the best modern immersion objectives is of the order $2 \times 10^{-5}$ cm., and there does not appear to be any prospect of this being materially bettered.

The limit of resolution of a microscope does not, however, by any means correspond to the smallest particle whose presence can be recognised by means of its image disc. The power of a microscope to render small particles visible is much greater, and depends essentially on three magnitudes: (1) the intensity of the illumination, (2) the difference in refractive indices of the particle and of the medium in which it is immersed, and (3) the readiness with which the eye can perceive a faint image-disc. The third requirement is much favoured if the image-discs are observed, not in the midst of a bright field of directly transmitted light, but on a dark background, and it is the essential feature of the ultra-microscope that none of the illuminating beam of light should enter the objective directly, but only such portions of it as are scattered by particles in the object. Any of the microscope systems affording dark ground illumination, such as were produced in great variety during the nineteenth century, can therefore reasonably be considered as ultra-microscopes, though the name is usually confined to those devices which combine this property with a very intense illumination of the object.

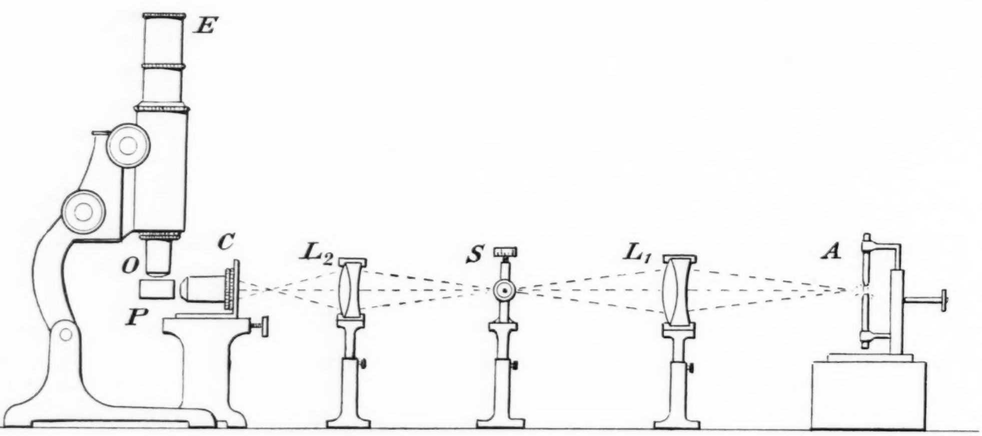



FIG. 1.—DIAGRAM OF THE SLIT ULTRA-MICROSCOPE.

The most famous ultra-microscopic system is that invented by Siedentopf and Zsigmondy in 1903, and known as the "slit ultra-microscope" (Fig. 1). Light from the sun, or from an arc lamp A, is focussed by means of the lens $L_1$ on the slit S, which is adjustable both as regards width and height by the screw-heads shown; a lens $L_2$ forms a quarter-size image of the illuminated slit in the focal plane of the condenser C (which is simply a microscope objective), and the latter throws a still further reduced image of the slit into the preparation P. This, if liquid, is contained in a small rectangular vessel with quartz windows. Light scattered by any small particles in the preparation enters the objective O, forming image-discs which are viewed by means of the eyepiece E. It will be observed that none of the illuminating beam enters the objective directly, and that the volume of preparation illuminated can be accurately delimited laterally and vertically by adjusting the width and height of the slit S. The length of the portion observed is limited by an eyepiece stop. It is thus possible to count the number of particles in a known volume of a colloidal solution; by evaporating a known volume of the latter to dryness, the total mass of the particles present can be calculated, and hence both the mass of a single particle and (supposing we know its density) its volume also.

### Counting Slides.

Many ultra-microscopes employ special condensers which allow the use of vertical illumination from below, such as is used in the ordinary microscope. A typical example of this pattern is the "Cardioid" condenser invented by Siedentopf (Fig. 2). The central part of the beam from the microscope mirror is blocked out by a stop S. The peripheral beams PP are brought to a focus F in the preparation by a series of reflections in the condenser C. The slide containing the preparation is brought into optical contact with the top surface of the condenser with cedar oil, as otherwise the oblique beams would be totally reflected at this surface, and would never emerge. Only light scattered from the preparation enters the objective O of the observing microscope.

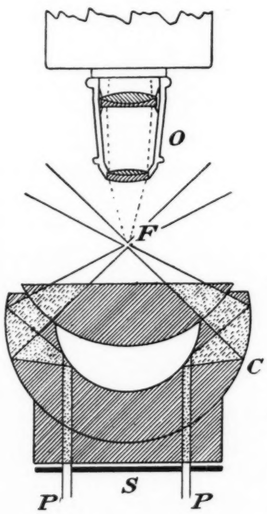



FIG. 2.—THE PATH OF THE LIGHT IN A CARDIOID CONDENSER.
The preparation (not shown) is placed at F.

In this type of ultra-microscope, the depth of the illuminated volume is somewhat indefinite, and for counting purposes a special slide is used (Fig. 3) similar to the haemacytometer used for blood counting. The central table is ground two-thousandths of a millimetre lower than the face of the slide, so that when a drop of liquid is enclosed between the table and the cover slip (surplus liquid running into the surrounding groove), a layer of known depth is obtained. The volume examined is limited laterally by an eyepiece stop. The intensity of illumination is so great in both the slit and the cardioid ultra-microscopes that glass slides fluoresce, spoiling the darkness of the background. The slides are therefore usually made of quartz, and are consequently expensive.

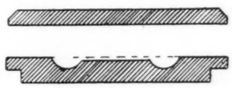


FIG. 3.—SECTION OF MICROSCOPE SLIDE AND COVER SLIP USED WITH THE CARDIOID CONDENSER.

Magnifications up to $\times 1500$ are used in ultra-microscopy, though mere magnification is not of primary importance, since it is never the structure, but only the image-disc of the particle that is observed, unless the object is, as occasionally happens, of ordinary microscopic dimensions in length, though ultra-microscopic in breadth.

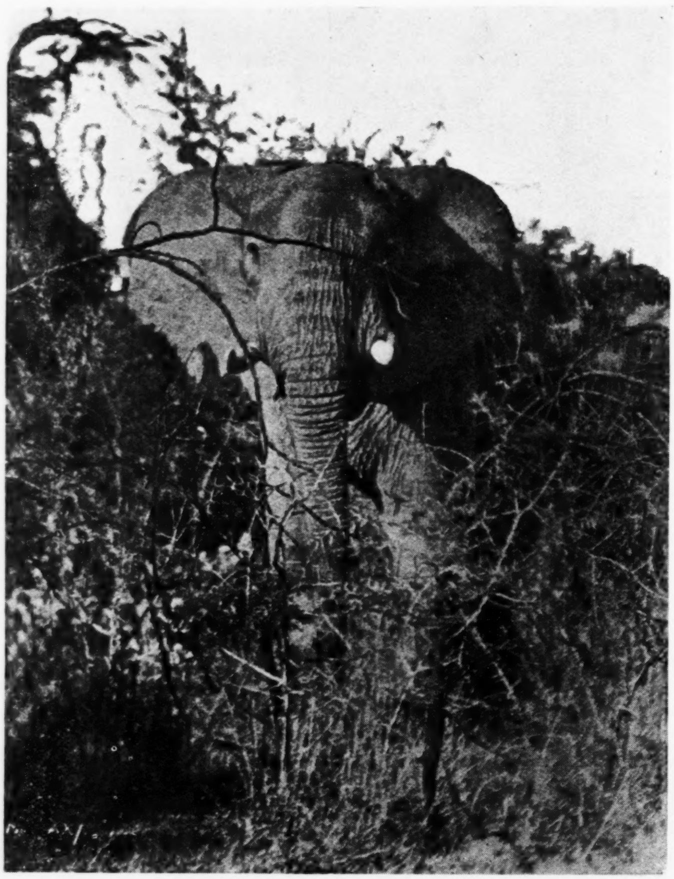
### Special Water.

On account of their very great refractive index, metallic particles are especially favorable objects for ultra-microscopic observation, and particles of gold have been separately observed which are as small as $1.7 \times 10^{-7}$ cm. in diameter. Still smaller particles exist in colloidal solutions, but these are not separately visible; their effects combine to give a general faint illumination of the field. Particles of starch, cellulose and other substances whose refractive indices approach that of the medium in which they are immersed, are only visible when of much greater size, and normally give rise only to a general illumination.

# Photographing Wild Elephants in Equatorial Africa.

*Mr. Marius Maxwell has recently published a book which has created a considerable sensation in both scientific and sporting circles. It is the most interesting book on big game photography yet produced, but it is also an absorbing study of the life of the wild elephant.*

THE camera is now established as an adjunct to the rifle, and in years not long to come it will, in all probability, supersede it for use on certain game. The whole question of the survival of certain African mammals outside the game reserves is not, however, a simple question of inducing that really extremely amiable and conventional person, the sportsman, to substitute films for cupro-nickel projectiles. The problem is more difficult than that. You cannot have farms and herds of elephants. The settler, not unreasonably, regards the visitation of an elephant herd which may eat off half his year's work on a young plantation of expensive plants as an unmitigated curse. This means that with the progressive agricultural and economic development of Africa, the pachyderms will vanish. Sentiment will not affect this matter. You can look on the African elephant as doomed.



A FACE-TO-FACE ENCOUNTER WITH A MASAI BULL ELEPHANT, AT A DISTANCE OF EIGHT YARDS.

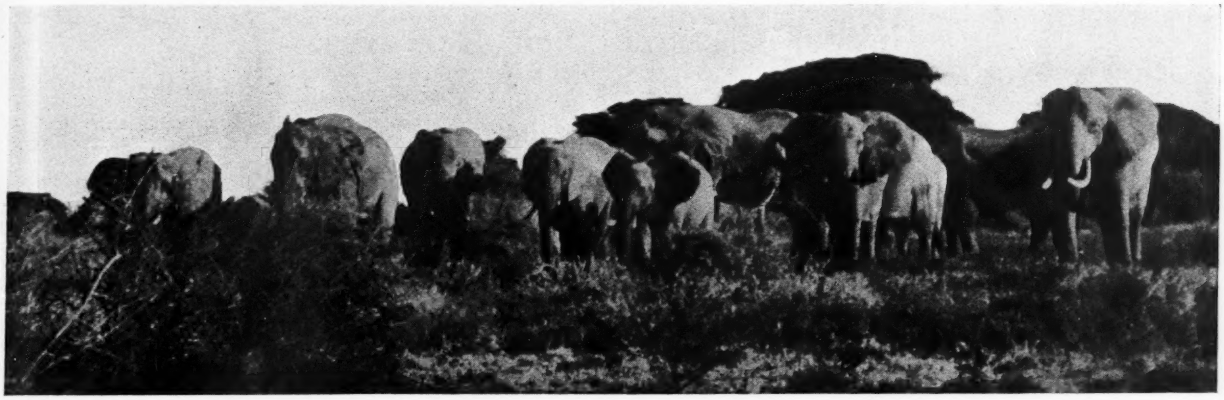
Mr. Marius Maxwell has recently published the most remarkable photographic study of the African elephant and some other game that has yet been achieved.*

There have been quite a number of recent enterprises dealing with African sport and illustrated by photographs. These have varied from abominable films of American provenance, to the recent work of a Scandinavian princeling, which aroused excusable mirth throughout Africa. It contained photographs supposed to be taken in the depths of the bush, but actually showing amiable pet animals in the East African equivalent of our Zoological Gardens. This is a book of entirely different character, undoubtedly the best book of its kind that has yet appeared.

Maxwell is more than a competent hunter, he is an elephant lover. Every chapter of his work betrays not only his technical efficiency in woodcraft and that most difficult art of working up to game, but his absolute mastery of his photographic armament and his intense love and joy in his subject.

These are the qualities which make all the difference between a book which is simply a volume of travel notes and sporting interest, and one which may prove to be a work of the utmost importance to generations yet to come, who will find the African elephant has

* "Stalking Big Game with a Camera in Equatorial Africa." Marius Maxwell. Medici Press. Twelve guineas net.



A HERD OF ELEPHANTS ADVANCING TO THE ATTACK. PHOTOGRAPHED AT ABBAS WEN.

vanished like his kinsman the mammoth. Mr. Maxwell's book can therefore be classed as a work of very general scientific interest, besides being one of the very finest photographic accomplishments of the year. Incidentally, it is thrillingly interesting from cover to cover.

The book has another unusual quality in that it is, so to speak, a complete textbook of how to photograph wild game. The author explains his methods and the why and how of every detail with logical completeness. Earlier work such as Schilling's was done very largely with telephoto lenses. In this book the majority of the really wonderful photographs are taken with an ordinary quarter-plate or five by four reflex camera. On occasion a Ross Xpres 16 in. telephoto combination was used, but the bulk of the work was done at close range in person and with an ordinary reflex camera.

This, in itself, is astonishingly good work, for large mammals are very definitely dangerous game and no armament, however powerful, is any argument against a herd of charging elephants. Mr. Maxwell spoke—I went to see him—with very real regret of the casualty which occurred when, in order to turn a charging herd, his companion was obliged to shoot a fine bull elephant.

His book shows the whole life-story of the elephants, their family life and all the conditions of their natural existence. Certain photographs of elephants show, in particular, points concerning muscular action and gait which could not have been ascertained under conditions of captivity. A kindred photograph shows giraffes in full gallop at thirty miles an hour. This settles once for all the doubts certain anatomists have suggested concerning the possibility of giraffes galloping.

In the course of the book one or two myths such as that of "elephant cemeteries" are destroyed. According to Maxwell, elephants naturally go away into the seclusion of the bush to die, and reports of elephant cemeteries are usually due to natives or ivory hunters having made an illegal holocaust of a small herd.

(*Continued on page 215.*)

A SECOND MEETING WITH THE SAME HERD.
The members of the herd are closing up and moving in a body towards their pursuers, the photographer and his hunter.

# Jelly Fishes and their Relatives.

**By Marie V. Lebour, D.Sc., F.Z.S.**

*What do you know about jelly fishes? Here is an article which is perfectly delightful, for it will help you to realize that the jelly fish is a useful and successful animal and not simply a nuisance to bathing parties.*

THE jelly fish is perfectly able to hold its own in the continuous and universal struggle for existence which is, perhaps, even more furious in the sea than it is on land. It may, therefore, be regarded as a successful animal, the conditions essential to success being briefly summarised thus :—

(1) To be able to procure sufficient food ;
(2) To protect itself from its enemies ;
(3) To reproduce its kind and to ensure food and protection for its offspring.

Jelly fishes and their allies have solved these problems satisfactorily, and have settled down in the animal kingdom as a large group with numerous members, and living in important and definite relations with other animals. All those plant-like animals known as zoophytes belong to this group, Hydra, the little fresh-water polyp of our streams and ponds, sea anemones, corals, sea pens and sea gooseberries, with numerous other rarer forms, all are relatives of the jelly fish, and the number and variety of these, together with their world-wide distribution, all bear witness to their success in life.

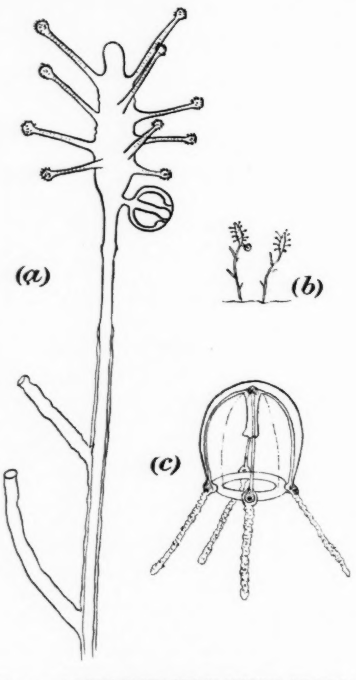



FIG. 1.—(*a*) HYDROID WITH YOUNG MEDUSA BUDDING OFF THE STEM.
The tentacles of the hydroid are armed at the the tips with stinging cells. Much enlarged. (*b*) The same, natural size.
(*c*) MEDUSA SET FREE FROM HYDROID.

### Stinging Cells.

The simplest of these is a tiny fixed cylindrical tube with a mouth at its free end, known as Protohydra, inhabiting brackish water. It was first discovered in the Oyster Parks at Ostend, but now is known in various localities in Britain. It is only about an eighth of an inch long, but it can capture and devour other animals, including worms, many times longer than itself. These it catches by means of stinging cells placed all over its surface (but especially round the mouth) which have a delicate mechanism by means of which barbs with a long thread connected with a poisonous fluid can be thrown out to stun the prey. These stinging cells, often elaborate and of great beauty, are the essential armature of nearly all the members of this group, and are used both for capturing the food and for defence. Bathers have often experienced the discomfort of these stinging cells from the larger jelly fishes swimming about round the coasts.

### Hydroids.

Next in complexity comes Hydra, the little fresh-water polyp, like Protohydra, but with the addition of tentacles round the mouth where the stinging cells are concentrated which are used in capturing prey. In the sea we have numbers of its relations. Hydra sends off simple branches, each of which drops off to form a separate individual like its parent. In many marine forms the parent is permanently branched, bearing numerous heads or polyps similar to Hydra, and therefore known as hydroids. In these there may be special receptacles bearing reproductive buds which are liberated as minute jelly fishes, or the jelly fish may be budded off direct from the hydroid (Fig. 1). These beautiful little glass-clear bells, the medusae, swim about in the sea and bear the eggs. Here we have a wonderfully efficient means of dispersal, and one essential to the well-being of the fixed community, which must not be overcrowded; for where would all the food be forthcoming for all the progeny of these large colonies? These little bells are at the mercy of winds, waves and currents, and may be carried very far from their original home. From the egg thus borne by the bell comes a free-swimming embryo which settles down and grows into a fixed hydroid similar to the original parent. This phenomenon of an asexual form alternating with a sexual form is known as alternation of generations, and is common in various groups of the animal kingdom.

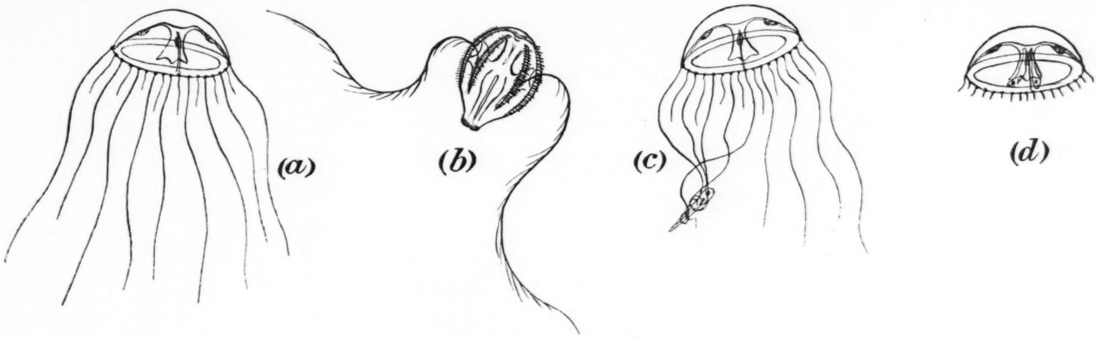



FIG. 2.—JELLY FISHES AND SEA GOOSEBERRY.
(a) Jelly Fish ready to feed. (b) Sea Gooseberry ready to feed. (c) Jelly Fish catching a baby fish. (d) Jelly Fish with two fishes inside. Being satisfied, it has withdrawn its tentacles.

The bell, or medusa, is shaped like a small umbrella with a "clapper" hanging from the under surface which bears the mouth. Round the bell margin are tentacles, and these tentacles are armed with stinging cells. This is the essential structure of all jelly fishes, large and small.

### How they Feed.

To catch the food the tentacles are outstretched to their fullest extent, sometimes many times the length of the bell. An unwary animal, possibly a baby fish, may knock against the tentacle and this immediately reacts, stinging the prey and entangling it. Sometimes a fight takes place, the fish being played just as an angler might play it, the tentacles being stretched out and retracted until finally the fish is exhausted, gives in, is transferred to the mouth and eaten. There is extraordinary strength in these delicate-looking tentacles, which are capable of sustaining a fish as long as the bell, sometimes longer. If we look at a larger jelly fish, the purple Aurelia so commonly thrown up on our beaches, we find its structure essentially the same. In its long folded lips guarding the mouth tiny embryos may be found, and these liberated in the water have a short free-swimming existence, but soon settle down and grow into fixed hydra-like forms on the sea bottom or attached to any convenient object. After some time constrictions are formed at regular intervals up the tube, the whole structure looking not unlike a pile of plates, and these are detached from the top downwards, each "plate" swimming away as a simple medusa with umbrella, clapper and tentacles. These tiny baby jelly fishes are rather less than a quarter of an inch across, but it takes them only a few months to grow to the full size, and if budded off from the fixed form in February the adults may be seen in thousands in the sea in July. Here again is a wonderfully efficient means of dispersal !

Sea anemones although fixed are provided amply with stinging cells, and are exceedingly voracious, being quite capable of swallowing fishes longer than themselves. In structure they are tube-like with a mouth at the free end surrounded by many tentacles which seize the food and push it into the mouth. Corals have the same structure but build skeletons, usually of lime. It is only in the beautifully transparent sea-gooseberries, which may be seen on clear days swimming in myriads in the sea, that there are no stinging cells, special adhesive cells taking their place. A fight between one of these sea-gooseberries about three-quarters of an inch long and fish about twice its size is a most exciting sight, sometimes one and sometimes the other being victorious. If the fish be caught it is eaten and digested, but it may escape, carrying away with it the long tentacle of its enemy.

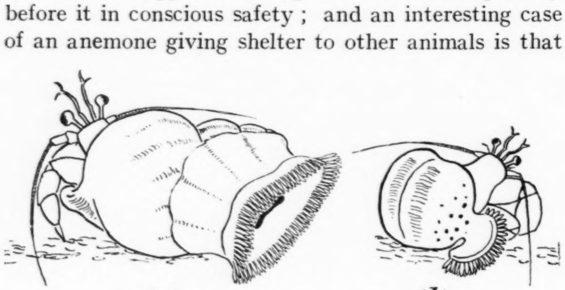
### Commensalism.

It is natural that such a successful group should be utilised to a large extent by other animals. In fact, pre-eminently is it of benefit to them in various ways of which we shall now give a few examples. Firstly, we have numerous cases of so-called commensalism, when two animals of quite different kinds pass their life together amicably so that each is of benefit to the other. Thus, in the well-known case of a hermit crab living inside the empty shell of a whelk, we find one kind has always a special sea anemone on the shell. The anemone has the advantage of procuring more food by being carried about from place to place, and the crab is protected by the stinging cells of the anemone.

The soldier crab, which lives in the empty shell of the "buckie," or common whelk, is the commonest, which carries the parasitic anemone. If the

anemone be taken away the crab will replace it and evidently has a great affection for it, and apparently dislikes very much being without it. The Velvet Cloak anemone is also common on our coasts, associated with the Little Hermit crab. This is a smaller crab which inhabits smaller kinds of shells such as the "necklace shells" (Natica). The anemone in this case so surrounds the shell that it is often hidden completely, the mouth and tentacles being in such a position that they come just under the crab near its mouth, and the food from the crab is thus easily caught (Fig. 3). Yet a third form of anemone is Colonial, forming a creeping root over stones and shells, often on shells containing the Smooth Hermit crab, and in this case the shell is absorbed by the anemone, the crab living in a soft case with no shell structure left.

Another well-known example is that of a tropical crab which always carries about a small anemone on each of its nippers, waving its claws triumphantly before it in conscious safety; and an interesting case of an anemone giving shelter to other animals is that



*(a)* *(b)*

FIG. 3.—HERMIT CRABS WITH ANEMONES.
(*a*) The Soldier Crab with Parasitic Anemone.
(*b*) The Little Hermit Crab with Velvet Cloak Anemone.

of the giant anemones found by Saville Kent inhabiting the Great Barrier Reef. These measure over two feet across, with tentacles covering the upper surface and surrounding the mouth. A little fish, brilliantly coloured with orange and white bands, swims about happily in the neighbourhood, and when any danger threatens it will pop into the mouth of the giant anemone, which never harms it and allows it to go in and out in perfect safety. A prawn with much the same colouring also takes advantage of the shelter of the anemone in the same way. The fish and prawn are clearly benefited by the refuge and shelter, and their bright colours may possibly serve as lures to other animals, which are thus brought within reach of the anemone's tentacles and captured.

**Omnibuses.**

Large jelly fishes afford shelter to many young fishes which accompany them in all their migrations, both vertical and horizontal. This is well known in the case of young whiting and also commonly with the young of the horse mackerel, which are often to be found near our coasts sheltering under the friendly bell of some large blue jelly fish. A small creature related to the sand hoppers is also constantly found with these large jelly fishes; firmly fixed with its claws in the tissues it indulges in joy rides which enable it to disperse its offspring in various directions and so enlarge its area of distribution.

The smaller jelly fishes are much utilised by larval animals which attach themselves to them for a portion of their existence. Thus the young of one of the sand-burrowing anemones (Peachia) clings to the tiny bells budded off by the hydroids and is transported for long distances. The baby anemone clings to the "clapper" of the bell, or to the bell margin, and the medusa is obliged to swim thus heavily laden with a burden nearly as large as itself (Fig. 4*c*).

Certain parasitic worms also utilise these small medusae and also sea-gooseberries for part of their larval life. A large group of these worms inhabit two or more kinds of animals during the course of their life history, the animals utilised being called the "hosts" of the worm. The best known instance is that of the liver fluke of the sheep, which starting as a free-swimming embryo, enters a small fresh-water snail in which it passes one phase of its larval life, then emerges and forms a cyst on a blade of grass in which it rests, to be eaten finally by a sheep and inside the sheep's liver becomes adult. In the sea one of these worms is known at first in a free-swimming larval stage with a spiny tail. This larva enters a jelly fish or sea-gooseberry and there rests, just as the liver fluke rests in a cyst on the grass blade, and in course of time, if a mackerel eats the jelly fish or sea-gooseberry, the worm may become adult in the internal organs of the mackerel. In this case the jelly fish, sea-gooseberry and mackerel are the hosts of the worm (Fig. 4*b*).

Sea spiders form a group of usually inert animals, the young of which frequently live parasitically on hydroids. One case is known in which the young of a sea spider on our coasts inhabits the free-swimming bells budded off from these hydroids, taking advantage of this method of transportation for its dispersal. The little sea-spider lies curled up in the "clapper" of the bell in perfect safety. There it grows to a certain size, finally dropping off its host to live a free existence (Fig. 4*a*).

The last instance of the utilization of this group is perhaps the most astonishing of them all. Many sea slugs feed upon hydroids, and whilst feeding necessarily many stinging cells are eaten. These are not digested, but they are in no way a hindrance to the predatory

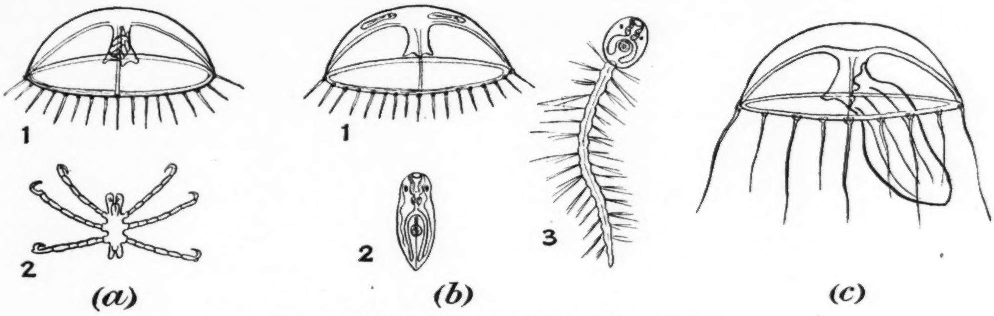



FIG. 4.—JELLY FISHES CARRYING LARVAL ANIMALS.
(a1) Small Jelly Fish carrying a larval Sea Spider. (a2) Young Sea Spider after it has emerged from the Jelly Fish.
(b1) Jelly Fish with parasitic Worm inside it. (b2) Worm, much enlarged. (b3) Free-swimming larva of Worm.
(c) Jelly Fish carrying young sand-burrowing Anemone.

one. Most animals avoid the hydroids and anemones because of these stinging cells, but the sea slug has learnt not only not to mind them, but actually to utilize them for its own needs, for we find these stinging cells are stored in special pouches connected with the animal's gut, and used for defensive purposes on its own account — a truly wonderful phenomenon.

In this small space we have endeavoured to give a brief outline of the lives of the members of one selected group of animals, and we find them inseparable from the lives of others. All are so interwoven that it is impossible to think of one apart from another. Either one preys upon the others or is itself preyed upon, or one helps the other or both are mutually helpful. A successful group such as we have outlined is bound to enter the lives of countless other creatures. Many other instances might be cited, but enough has been said to show that the jelly fish is pre-eminently a successful animal and as such is able, in a peculiar number of ways, to influence the lives of other animals in the sea.

## NIGHT FISHING FOR INSECTS.

THE entomologist has long been accustomed to use a lantern for securing moths and night-moving Coleoptera. The poacher knows the utility of a lantern for attracting fish. The freshwater biologist or microscopist may be interested to learn that he can apply the same methods with extraordinary success.

A flashlight bulb and socket attached to long waterproof wires should be corked into a stout test tube which has been weighted with sufficient lead shot to sink the apparatus. The other ends of the leads are carried to a pocket flashlight case.

The lamp is sunk in a convenient spot in shallow water, preferably over a wide muslin net. When switched on the light attracts numerous crustacea such as Daphnea Estromoscata and Cyclops. Planarians and Vermes of all kinds swim to the centre of attraction and one can watch the water-life gyrating round the submerged globe just as midges swarm round a lighted table lamp.

The yield of larval forms concentrated by the lamp attraction over the net is sometimes astonishingly heavy, and far more productive than the usual habit of casual sweeping.

The same plan can be followed at the seaside and astonishing crops of marine life gathered in rockpools, harbours, or from a boat at sea. The response of many of the lower forms to light effects is not yet perfectly understood. Certain flights or swarms of insects only take place at certain quarters of the moon, and a development of this night-fishing for insects may be of value in determining fresh facts about the mating habits of planktonic forms.

## MICROSCOPIC IDENTIFICATION OF COAL.

HARD coal has long resisted the efforts of microscopists. A new technique evolved by Professor H. E. Turner, now of Lehigh University, reveals the vegetable structure in anthracite.

A slab is finely polished then dried out at a temperature rather less than red heat. The surface is then heated to dull redness for a few minutes in a blowpipe flame. This etches the surface and the structure is revealed. A curious result is that there appears to be no deformation of cell structure in even the hardest coals. There are signs of heating but none of pressure. This is contrary to the commonly accepted theory of the formation of hard coal from soft coal under pressure.

# Alchemy in Islam.

**By E. J. Holmyard, M.A., F.I.C.**

*There are no longer alchemists in the West but in the East they still exist and work on the old formulæ contained in Arabic MSS. Their ancestors striving to transmute base metal into gold laid the foundations of modern chemical science.*

ALCHEMY is not yet dead. Last year the Chemical Laboratory at Clifton College had the unique experience of witnessing attempts at transmutation by a genuine alchemist in the person of a venerable and learned Arab Shaikh from Medina. The experiments were, alas ! unsuccessful, but this unfortunate result the Shaikh attributed to the fact that our muffle furnaces and oxy-hydrogen flames gave such ridiculously low temperatures. His textbook (a manuscript copy of a work alleged to be of the seventh century) postulated that the heat employed should be greater than that of Hell, figures for which have very negligently been omitted by Messrs. Kaye and Laby from their book of tables. Unperturbed, however, by the failure of the "great magistery," the Shaikh demonstrated to a throng of eager spectators—suffering slightly from *ennui* after a course of Higher Certificate chemistry—the preparation of an Elixir "for the stomach" from orpiment, sulphur, milk, honey, castor-oil and oil of violets.

### Jews and the Prophet.

This continued vitality of beliefs of a bygone age may serve to remind us that, long before the Norman Conquest of England, the science of chemistry had reached a very high stage of development among the followers of the Prophet. The study of Muslim chemistry offers many attractions to the historian who is also a chemist, but here we may leave the wise to ponder, and gain a little amusement from the lighter side of the subject. There is no lack of material relating to alchemy in Arabic literature, and as we are not concerned in this article with the formidable problem of authenticity, we may draw freely whence we will.

The idea of a wonderful substance which would transmute the base metals into gold, appears to have been imported into Islam in very early days. According to one story, the Prophet himself was an adept : "The Jews came to him and asked him concerning alchemy, and he said, 'If I will that the camels from Tihama come to me laden with gold and silver, verily it is so ; lift ye up the reed mat.' They lifted it and saw underneath it a large quantity of gold. Then said the Jews, 'That and the like can the magicians also do.' The Prophet replied, saying, 'If I reveal this Art to you, will ye then accept Islam ?' The Jews answered, 'Yea.' Thereupon the Prophet said, 'The substance of alchemy is made from common gold, lead, bitter salt and ordinary quicksilver. Yet will ye not believe !'" We can, perhaps, hardly blame them.

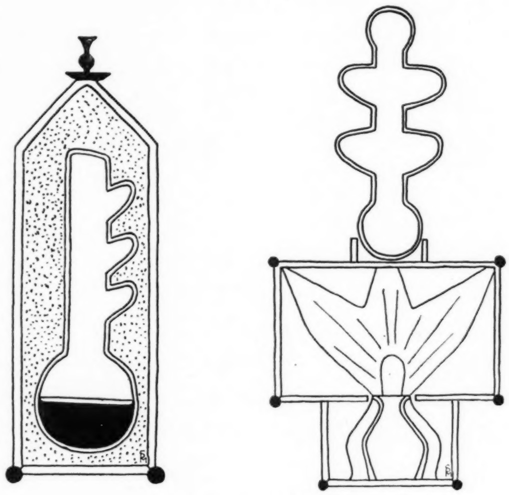
### Cryptic Formula.

The Prophet's cousin and son-in-law, Ali, who was Caliph from 656 till 661, has always been claimed by the alchemists as one of their number. It is said that certain Muslims, wishing to have their minds set at rest upon the important question of the existence or non-existence of the Elixir, went to Ali and said, "O Commander of the Faithful, does the Elixir exist or does it not ?" Ali replied, "Certainly it has existed, exists now and will continue to exist." Having been requested by his audience to give further particulars, he continued, "Verily in lead and vitriol and quivering quicksilver, in crocus of iron and in verdigris, there are treasures attainable."

The Believers were not yet satisfied and said, "Explain further, O Commander of the Faithful." So he said, "Make half of it water and the other half earth, then fertilise the earth with the water. It is finished." Somewhat naturally this still failed to convey much information to the seekers after knowledge, who petitioned the Caliph again. Ali, however, was not to be drawn, and closed the discussion with the remark, "There is nothing further, and the philosophers [*i.e.*, the Greek philosophers], added nothing more. Had they done so, the vulgar would have made a jest thereof."

Towards the end of the seventh century, the Omayyad prince Khalid ibn Yazid busied himself with alchemy. A Muslim encyclopaedia of about A.D. 1000 asserts that "the first to investigate the books of the ancients upon alchemy was Khalid ibn Yazid. He was a preacher, a poet, eloquent, and full of enthusiasm and judgment. He was the first to have translated the [ancient] books on medicine, astrology and alchemy. Of a generous nature, it is related that, in answer to one who said to him, 'You

have devoted the greater part of your life to the pursuit of this Art,' he cried, 'All my researches have for their sole aim the enrichment of my brethren and companions. I had hoped for the Caliphate, but that has been taken from me, and I have found no compensation except in attempting to reach the utmost limits of the Art



ALCHEMICAL INSTRUMENTS
From Berthelot's Syriac MS.

of Alchemy. I wish to render all my acquaintances—even those known to me for only a single day—independent of the necessity of soliciting favours from a prince.' It is reported—and Allah knows best whether it is true!—that Khalid was successful in his alchemical undertakings. He wrote on the subject a number of treatises and opuscules and composed much verse on the matter."

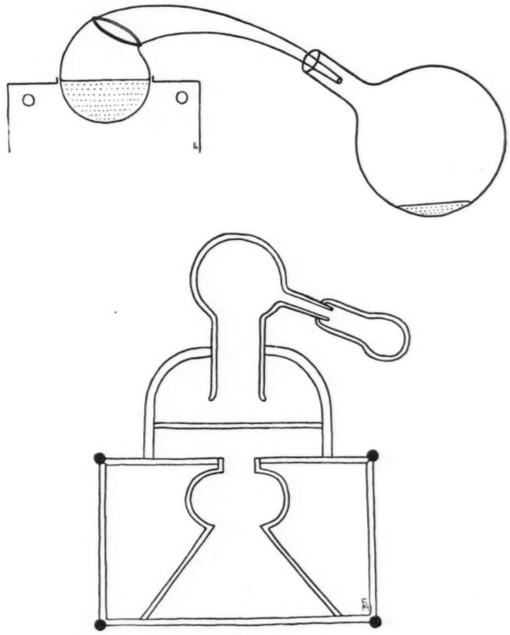
A verse ascribed to Khalid is quoted by the historian Mas'udi (died *c.* 956) in his great work "The Prairies of Gold." Mas'udi seems to have been a sceptic.

**Lost Book.**

He says," Details concerning those who employ their time in the transmutation of the metals, gold, silver, precious stones, pearls, etc.; the preparation of Elixirs of all kinds, such as *ferrar* and others, the solidification of mercury and its conversion into silver, the chicanery and tricks of all descriptions which they accomplish with the aid of their retorts and alembics, and distillation, calcination, the use of borax, wood, charcoal and bellows; in short, the story of the ingenious expedients which they apply to their researches, the frauds and ruses to which they have recourse, all this will be found in our 'Historical Annals' [a work which is unfortunately not extant]. We give there some of their poems on this subject and their traditions concerning the ancient Greek and Byzantine alchemists, such as Queen Cleopatra and the Prophetess Maria, and finally we quote the celebrated alchemical formula of Khalid, whom the adepts recognise as one of their authorities—a formula expressed in a piece of verse from which the following lines are taken :—

> 'Take talc with *Ushshaq* and with that which
> is found on the roads ;
> Take a substance which resembles borax and
> weigh them without error ;
> Then, if thou lovest the Lord thou wilt be
> master of Nature.'

"There is a little work in two parts on this subject by Ya'qub al-Kindi [ninth century] ; he shows in it the impossibility for man of rivalling the creative power of nature, and exposes the lies and tricks of the adepts of this Art. His book is entitled 'A Refutation of the pretended methods of preparing gold and silver artificially.' This work of al-Kindi was answered by Abu Bekr Muhammad Razi [died 923 or 932], the



RETORTS AND ALEMBICS SHOWN IN ARABIC MS.

philosopher [known to the West as *Rhazes*], the author of the 'Kitab al-Mansuri,' a work on medicine in two sections. Razi shows the falsity of the allegations of Al-Kindi and demonstrates the possibility of transmutation. . . . As for me, may God preserve me from applying myself to researches which weaken the brain, ruin the sight, and yellow the skin, in the

midst of the vapours of sublimation and the exhalations of vitriols and other minerals ! "

The wealthy Barmecide family, which wielded practically unlimited power under the Caliph Harun al-Rashid (786-808), encouraged learning of all kinds. Certain members of the family appear to have dabbled in chemistry themselves, under the guidance of the greatest chemist of Islam, Jabir ibn Hayyan. Some accounts make Jabir—or, to give his name its Western dress, Geber—a Sabian of Harran in Mesopotamia. Harran had been a home of Greek culture ever since the days of Alexander the Great, and its inhabitants were famous for their intellectual achievements. Although they were pagans, they met with favour at the Court at Baghdad, on account of their learning, but it is said that to ensure their safety they found it necessary to pay a considerable sum in the way of bribes to the conscientious Muslim officials.

**Early Best Seller.**

Jabir himself was not only an indefatigable experimenter ; he had such skill with his pen that he became a " best seller," and his treatises on chemistry had an enormous circulation throughout the scientific world. In some of them he gives us interesting details of his private life, from which it may be gathered that he was an intimate friend of Harun al-Rashid's famous ministers. " Yahya ibn Khalid the Barmecide," he says on one occasion, " had a very valuable handmaiden, unequalled in beauty and perfection and deportment and accomplishments. One day she fell ill and finally became delirious. A messenger came to Yahya with the news and he asked me what I advised. As I had not seen her I thought she might be poisoned, so I recommended the administration of cold water. This treatment was of no avail, so I ordered them to poultice her abdomen with heated salt and to chafe her feet. As she still grew worse, Yahya at last asked me to go and see her, and I found her at the point of death from some obscure disease. Now, I had an Elixir with me, so I gave her a draught of two grains of it in three ounces of oxymel, and, by Allah ! the sickness departed from the damsel and within the space of half an hour she was as well as ever. Yahya fell at my feet and kissed them, but I said, 'Do not so, O my brother.' And he asked me about the uses of the Elixir, and I gave him the remainder of it, explaining how it was employed, whereupon he applied himself to the study of science and persevered until he knew many things ; but his son Ja'far was cleverer than he."

PAGE FROM ARAB CHEMICAL MS. IN BRITISH MUSEUM.

Jabir was not so much obsessed by the chimæra of transmutation as were many of his successors, but frequently turned his attention to the applications of chemistry in the arts. There can, however, be no doubt that he believed himself to have successfully accomplished the conversion of the baser metals into gold, and there are many legends of such transmutation in later writers. The following account was discovered by Prof. H. E. Stapleton in a manuscript in India, and published by him in 1910 :—" Dubais ibn Malik said, 'I was living at Antioch, where I had settled, and there I had a friend who was a jeweller by profession, to whose shop I often resorted. Now, as we were talking together one day, a man came in, and having saluted, took his seat. After a while he removed from his arm an armlet which he handed to my friend. It was set

with four jewels, and an amulet of red gold was fitted into it. On the amulet was inlaid a clear inscription in green emerald, which read as follows: ***Al-Hakim-bi-amrillah puts his trust in God*** [Al-Hakim-bi-amrillah was the Fatimid King of Egypt from A.D. 996-1020]. I was astounded at the fineness of those jewels, the like of which I had never before seen, nor had I ever thought to see the like in the world, and it occurred to me that this amulet must have been stolen from the treasury of Al-Hakim, or it might have fallen from his arm, and this man had picked it up, since such jewels are to be found only in the treasuries of kings, or among their heirlooms.'

"It was finally purchased by Dubais for 3000 dinars. Inside the amulet was found a manuscript, pronounced by Dubais, who was acquainted with the shaky handwriting of Al-Hakim, to be the autograph of that king, containing an account of two Ways of making the Red Elixir, according to the method of Moses and the rest of the Prophets as handed down by the Imam Ja'far al-Sadiq [reputed teacher of Jabir]. Dubais was successful in carrying out the operations, both of the Lesser Way, whereby an Elixir was made capable of converting 500 times its own weight of base metal into gold, and those of the Greater Way, whereby an Elixir was prepared, of which only one dram was required for the conversion of 3000 drams of base metal."

### Real Utility.

Intermingled with these fanciful stories of transmutation we find quite a large body of sound chemical knowledge. In a book attributed to the celebrated Jabir there is, for instance, a clear account of the preparation of nitric acid. Whether the work in which it occurs is genuine or not I cannot say, but since this is, I believe, the first occasion on which directions for making nitric acid have been discovered in any Arabic book passing under Jabir's name, it may be of interest to put the passage on record here. It appears to have been taken by Jabir from a book brought to Al-Fadl, son of Yahya the Barmecide, by a man from Khorassan, and purchased by Al-Fadl for 10,000 dinars after he had been assured that it was complete. The description runs as follows:—"Take five parts of pure flowers of nitre, three parts of Cyprus vitriol and two parts of Yaman alum. Powder them well, separately, until they are like dust and then place them in a flask. Plug the latter with palm fibre and attach a glass receiver to it. Then invert the apparatus and heat the upper portion [*i.e.*, the flask containing the mixture] with a gentle fire. There will flow down, by reason of the heat, an oil like cow's butter" [which is, of course, an oil in hot countries]. It is interesting to compare these instructions with those given in the Latin work "The Invention of Perfection" ascribed to Jabir (Geber): "First take of vitriol of Cyprus, *lib.* i; of saltpeter, *lib.* ii, and of Jamenous Allom one fourth part. Extract the water with Redness of the Alembic."

### Rare Illustrations.

Figures of the apparatus employed by these ancient chemists are rare in Arabic manuscripts, but descriptions are fortunately quite common. A list is given by Al-Razi in his "Book of Secrets," by the author of the "Keys of the Sciences" and by many other writers. The principal items were furnaces, crucibles, alembics, aludels and receivers, and the chief operations were distillation, sublimation and crystallization. The separation of gold from silver, and of the latter from lead, was well understood, and the process of cupellation is clearly described in a work of the eleventh century. Some of the types of utensils which were in common use are shown in the accompanying figures, which were reproduced by Berthelot from a Syriac manuscript. They have been re-drawn from Berthelot's illustrations by a member of the Sixth Form at Clifton College, Mr. S. R. McE. Porter, to whom my thanks are due. The other illustration in this article is a reproduction of a page of an Arabic alchemical manuscript in the British Museum. It is of no great antiquity.

## PHOTOGRAPHING WILD ELEPHANTS IN EQUATORIAL AFRICA.

(*Continued from page 207.*)

Such collections of bones are invariably found to be without their ivory.

Valuable appendices discuss palaentological predecessors among the proboscidae and debate the question of man's responsibility for the extinction of the mammoth. The author's conclusions are entirely against this theory, and, basing his arguments on the known practices of races in an early state of development to-day, he points out that the resources of the scattered communities of early European man would not have been equal to the task. Later races, in spite of the development of better weapons and the probable use of vegetable poisons, would hardly have been more successful.

The passing of the mammoths was probably due to a deterioration of the race.

The five years spent by Mr. Maxwell on his study of the elephant have not been wasted. He has produced a book which is not only beautiful and absorbingly interesting, but which will endure possibly longer than the elephant.

# The Use of Steam.

**By David Brownlie, B.Sc. (Hons.), Lond., F.C.S., M.I.Chem.E., A.M.I.Min.E.**

*A fascinating record of the whole history of steam for the past 2,000 years. The author shows how the discoveries of British engineers have developed steam power to its present stage of operation at 3,200 lb. pressure.*

FROM the history of science there is waiting to be extracted almost countless stories of discovery, just as interesting and exciting, and infinitely more important to humanity, than the better known and apparently more readable accounts of travel and adventure with which the term "discovery" is popularly associated. It is, however, a sign of the times that we have to-day in Great Britain a "Newcomen" Society for the study of the history of engineering, and attempts are being made in the United States to place the historical study of science on a sound footing.

Perhaps one of the most interesting subjects from the point of discovery in science is that of the use of steam. Water was of course first boiled untold thousands of years ago, and primitive man before he invented pots and vessels, first of earthenware and then of metal to stand the fire, probably boiled his water in vessels constructed of clay daubed on a framework of basket and filled with cold water, into which he placed red-hot stones from the fire. The idea of using the steam that was given off in order to perform useful work was almost certainly not arrived at for a vast period of time. The first definite reference in history to the use of steam is that of Hero of Alexandria who somewhere about 150 B.C. devised his well-known "turbine" in which steam issuing from a number of nozzles caused a revolution of a metal ball in which the water was boiled.

## Egypt's Lead.

It has always been believed, though without certainty, that the priests of Egypt used in some way the expansive force of steam, generated in underground chambers, to open heavy temple doors in a mysterious fashion so as to terrorise and exploit the ignorant population, and this secret was kept by them for centuries. There are in history many tantalising and fragmentary references to what was apparently the use of steam. Thus it is stated the clocks in the Cathedral of Rheims about the year 1125 were worked by "air escaping from a vessel of heated water." We have also mention of men like Beasco de Garay in Spain (1543) who is said to have invented a steam boat, although it is now proved that this was only an improved manual-driven boat; Matthesius in 1571; Soloman de Caus in 1615, who seems to have been the first man to raise water by steam; and Giovanni Branco in 1629 who produced a crude form of the impulse steam turbine. The first authentic reference in English literature to the application of steam would appear to be a patent granted on the 21st Jan., 1630, to David Ramseye "*to raise water from low pitts by steam.*" Following this we come to the famous Marquis of Worcester, the French inventor Denis Papin, and Captain Thomas Savery, a retired British Naval captain, who is apparently the first man in the world to have used steam on a really practical scale from a boiler under pressure. The history of steam about this period—say, 1650-1700—is, however, very obscure and much more research work upon the matter is needed.

## Lost History.

The Marquis of Worcester carried out his famous experiments at his ancestral home, Raglan Castle in Wales, and undoubtedly had the most extensive workshops and experimental laboratories. Unfortunately not a trace of these or his many inventions remain, and all there is to be seen at Raglan are certainly mysterious grooves and excavations in the wall of the castle keep, which are said to have contained his steam pumping engine. The first mention he makes of this is in a letter 26th Jan., 1660, and there seems now to be no doubt that he obtained much of his idea in this connection from an unfortunate French inventor Jean Francois. The latter devised a steam pumping "engine" the principle of which he partly describes in a very rare book written by him and published in 1655, a copy of which is in the Patent Office Library, London. Francois was locked up in a Paris prison as a madman, and was there visited by the Marquis of Worcester who used to make periodic trips to the Continent where very much greater interest was being displayed in scientific matters. (This somehow has a familiar ring to-day !)

The general application of the use of steam by the early pioneers, such as Francois, the Marquis of Worcester, Denis Papin, and Savery about this period, was approxi-

mately the principle we know as the pulsometer pump. That is to say, steam was generated under pressure in a closed vessel or boiler by heating water contained in it by means of a fire underneath. This steam was then blown through a pipe into a second vessel full of water, pressing on the top of the water and forcing it out through a pipe connected to the bottom which would discharge the water to a very considerable height—say 20-60 feet. When the second vessel or pump chamber was nearly emptied of water the supply of steam was shut off, and in consequence the steam with which the vessel was filled instantly condensed.

### Vacuum.

The vacuum so formed then sucked up violently through another pipe, the valve of which was opened for the occasion, a fresh charge of water to almost refill the vessel. The valves were then reversed, there being generally two such water or pump chambers side by side worked alternately, steam allowed to enter and the water contents forced out as before to a great height, giving therefore a comparatively powerful and almost steady pump much superior to the ram pump devices then in use worked by horses walking round in a circle. Francois seems to have used this essentially "pulsometer" method, and the Marquis of Worcester's engine was clearly on these lines although he describes it in such vague and flamboyant language, terming it the "semi-omnipotent engine," that it is difficult to say what he really did accomplish. However, it is known that he was able to pump water to a great height, apparently about 40 feet, by means of steam at Raglan Castle, and he erected a second pump at Vauxhall in London, which pumped four large buckets of water a minute to a height of 40 feet. We only possess accounts of this steam pump from two eye-witnesses, who were both foreigners—M. Sobiere, historian to the King of France, who mentions it in his book of 1664, and the Grand Duke of Tuscany who visited it 23rd May, 1669.

18 L'Art d'éleuer l'Eau sur sa source,

dante attirera l'air par N. T. du vase C. qui se rarefiera, ou attirera l'eau de A. autremét il s'ensuiuroit du vuide: & d'autant que l'air resistera plus à vne grande rareté, que l'eau a l'attraction & eleuation; à cause de l'abondance de l'eau que ie suppose s'écouler par F. cette-cy attirera l'eau de A. par l'air premierement rarefié; puis resistant à vne plus grande rarefaction, l'attirera, dis-je, jusques à R. d'où elle tombera dans le reseruoir C. & de là elle sera conduite par le robinet H. où on desirera. Il n'est pas besoin que l'eau vienne en B. de A. ny que ces deux eaux soient ensemble ou de niueau; l'vne peut estre d'vn costé de la montagne, l'autre d'vn autre: celle de A. doit estre d'eau claire pour monter & seruir à boire, cóme est l'eau d'vne source, d'vn puys, d'vne fontaine; & pour B. toute eau est suffisante, pource qu'elle ne sert que pour attirer l'autre, si on ne l'employoit à tourner vne roüe. La capacité B. doit estre grande, & peut estre faite en forme de cisterne, auec du bon & fort mastic, afin de contenir beaucoup d'eau, & condenser par sa froideur l'air qui doit succeder à l'eau coulante.

Il y en a qui adjoustent vn troisiesme moyen d'éleuer l'eau sur sa source par l'eau mesme: Sçauoir est par vn tuyau recourbé, & éleué sur ses extremitez: car si l'extremité par où l'eau doit sortir est plus basse que celle par où l'eau doit entrer, on n'a qu'à attirer l'air par aspiration pour faire suiure l'eau: & depuis qu'il en sera vne fois remply il commencera à couler par l'extremité plus basse, & continuëra ce mouuement tant qu'il y aura de l'eau en l'autre plus haute; pource que la partie de l'eau descendante est plus forte que la montante, & le mesme demeurant le mesme, fait tousiours le mesme. Et de là ils se persuadent pouuoir transporter l'eau d'vne source qui sera dans vn costé d'vne montagne, comme dans l'Occidental, en vn lieu plus bas du costé opposite comme de l'Oriental, par le moyen d'vn tuyau qui monteroit iusques au haut de la montagne, puis redescendroit plus bas, & ne seroit different de la chantepleure que comme le grand l'est du petit semblable. Ce qui certes seruiroit à plusieurs maisons; & mesme ils pretendent en ce cas par vne maniere de pompe, de pouuoir tirer l'eau qui passe par tels tuyaux, soit tout au haut, soit en d'autres endroits; & c'est auec la facilité comme si la source estoit en tel lieu. Ausquels ie responds premierement, que cela ne se peut quand le tuyau monte sur la source plus haut de 31. pieds: ce que les experiences nouuelles nous ont appris. Ie dis secondement, qu'absolument parlant cela se peut, quand la montée de l'eau ne passe pas trente pieds enuiron: mais les difficultez qui se rencontrent soit à remplir

SPECIMEN PAGE FROM FRANCOIS' BOOK. "LA SCIENCE DES EAUX," PUBLISHED IN PARIS, 1655.

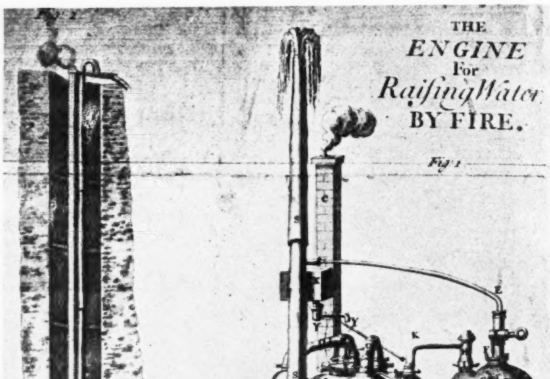
### Early Writers.

Denis Papin, the famous French engineer, was another remarkable man, and his name is still familiar to-day in the form of Papin's "Digester" for making tough fowls tender by boiling them under slight steam pressure. Papin, who was expelled from France on religious grounds, resided for a long time in Germany, and in 1707 is stated to have invented the first steam-propelled vessel which he set to work on the river at Hanover. This vessel was, however, destroyed by a mob. Papin is often claimed to be the first definite inventor of the principle of using steam to fill a space, driving out the air and then being condensed, so causing a vacuum. This, however, would not appear to be the case, since, as we have already seen, Francois published his book in 1655 and the Marquis of Worcester completed his engine somewhere about 1660.

Papin is also stated to have invented in 1690 a mechanical apparatus with a piston and cylinder in which the piston was forced up by steam, apparently generated in the cylinder itself by a fire underneath. When this fire was removed, the steam slowly condensed as the whole arrangement cooled and the piston was gradually sucked down by the vacuum and could be used to lift a weight, thus storing up energy. It is believed he used an appliance on these lines for his steamship engine.

Thomas Savery took out a patent for his famous

steam pump, which essentially embodies the principle of the modern pulsometer, on the 5th July, 1698. Almost a year later he showed a working model of his invention to the meeting of the Royal Society at Gresham College (London). In 1702 he published his well-known and very scarce pamphlet, "The Miner's Friend," describing the whole invention in detail in the most lucid manner. The title page states that it was printed by S. Crouch at the Corner of Popes Head Alley, Cornhill, London, and it is addressed in the quaint phraseology of the time "to the Gentlemen adventurers in the mines of England." He states that his apparatus with a 3-inch-bore pipe will pump water 60 feet high and requires a fireplace only 20 inches deep and 14-15 inches wide, the "great boyler" being 24-30 inches wide, constructed of beaten copper, whilst the clacks (valves), valve boxes, cocks, pipes and regulators were all of brass. The valves were operated by hand and the whole design and construction is a very fine piece of work, whilst the directions for operating the pump and the description of its method of working, together with a discussion of the objections raised against it, are given, as already mentioned, in the clearest and most lucid fashion, quite different to the vague and pompous language of the Marquis of Worcester.



FRONTISPIECE ILLUSTRATION OF SAVERY'S PUMP, FROM "THE MINER'S FRIEND."

## A Pioneer.

Savery was unquestionably a man of very high scientific attainments and vision, and more than anyone else can be regarded as the real pioneer of the use of steam. Unfortunately his invention, although it operated perfectly, was not a commercial success for the very vital reason that he could not find craftsmen able to construct copper boilers strong enough to withstand the pressure necessary, apparently some 30-40 lb. per square inch, so that, efficient and scientific though it was, it could not compete against the Newcomen atmospheric engine. The lack of craftsmen was due primarily to the destruction of the mediaeval guilds throughout the whole of Europe, with their knowledge of skilled craftsmanship. If Savery had lived in the time of Leonardo da Vinci, Michael Angelo, or Benvenuto Cellini he would have found much less difficulty in having his copper boilers constructed, because of the high degree of proficiency of the guild workmen—to whom we owe, for example, our fine ancient cathedrals with their unique stained glass-work and beautiful work in metals.

Newcomen was a Dartmouth blacksmith, and is claimed to be the original inventor of the piston. His famous atmospheric engine consisted in admitting steam to a cylinder at only 1 lb. pressure, the piston rising by means of a weight. The steam in the cylinder was then condensed by squirting in water, when the vacuum formed caused the piston to descend instantly, thus giving a reciprocating pump. This engine prospered exceedingly because there was no difficulty in constructing a boiler for such conditions, and this now leads us to James Watt and Richard Trevithick.

The life and work of Watt is more or less known

to everyone, and his memory is immortalised by the discovery of the modern engine in which the steam is used to push the piston with the separate condenser, the famous firm of Boulton and Watt in Birmingham being the first steam engine builders. Richard Trevithick, however, who was probably the greatest engineer that ever lived, has had scant justice done to his memory, and his life and achievements are in their way almost as wonderful as those of Michael Angelo or Leonardo da Vinci already mentioned.

### Trevithick's Reward.

Trevithick is the pioneer of the modern high-pressure steam boiler, the internally fired cylindrical "Cornish" boiler, named after his native county of Cornwall, which he invented somewhere about 1797. In 1800 he put down an engine and boiler plant at the Cooks' Kitchen Mine in Cornwall which operated at 25 lb. per square inch pressure, to the horror of Watt, who regarded 6 lb. pressure as the practical limit. He also invented many auxiliaries to the boiler and steam engine, including the gauge glass and the steam blast in the chimney, and was the true pioneer of the railway, having invented and constructed the first steam locomotive in the world apart from small models, which ran on the roads in Cornwall. Subsequently, he built his famous "Catch-me-who-can" locomotive that was exhibited in London, and built the first railway in the world, between Merthyr Tydvil and a colliery 25 miles away, years before Stephenson was ever associated with the locomotive. Among other things he invented the steam dredger and was rewarded for the incalculable services he rendered to humanity by being buried in an unnamed pauper's grave at Dorking near London.

From the days of Trevithick the history of steam has been largely one long struggle to increase the boiler pressure so as to improve the thermal efficiency of the steam engine or turbine. Trevithick's design of boiler was soon able to work at 40-50 lb. pressure, and the "Lancashire" boiler, a minor modification, has during the past 80 years gradually enabled the pressure to be raised to 200 lb. per square inch, although the average industrial steam pressure to-day is still only about 100-180 lb. Similarly the water-tube boiler, another long and fascinating story, enabled us, until only a few years ago, to work at 200 lb., and sometimes 250 lb. But only recently, within the last 10 years, a wonderful advance has been made as regards boiler pressure. To-day the standard super-power station water-tube boiler works at 350 lb., and boilers are being constructed to work at anything between 350 and 600 lb.

### Modern Developments.

The most remarkable of all is, perhaps, the super-pressure steam generator which has made astonishing progress during the past five years. To-day boilers are being constructed in the United States with drums of solid steel forgings instead of plates and weighing 70 tons each, to work at no less than 1,200 lb. pressure, and similar work is being undertaken in Germany. Finally the steam generator or boiler composed entirely of small-bore steel tubes offers the most astonishing propsects of all. Blomquist in Sweden is running at 1,500 lb. pressure with a steam generator composed of revolving straight steel tubes 12 inches diameter, and now Benson has erected in Rugby a coil generator built up of $\frac{3}{4}$-in. steel tubes which operates at the amazing pressure of 3,200 lb. pressure. This represents the actual "critical" conditions under which water at about 706° F., occupying three times the volume when at 60° F., is bodily converted into steam at the same volume without any ebullition or boiling and therefore with no absorption of latent heat—an amazing achievement. It is a far cry from Trevithick who foresaw that the future of the steam engine depended on high pressures, and who prophesied he would one day work at 200 lb., whilst he is actually said to have risked his life by attaining 140 lb., and to James Watt who, towards the end of his life, erected engines at 10 lb. pressure; but the story of steam to date is certainly as fascinating as anything in the whole realm of discovery, and the end is not yet.

## ORIENTAL CRABS INVADE EUROPE.

CHINESE crabs have been discovered near Brunnsbüttel on the lower Elbe. So far some fifteen specimens of both sexes have been discovered. The invader is *Eriocheir Sinensis*, one of the family of *Grapsidae*, and is somewhat akin to the European species found in the Sea of Marmora, and a near relation of the *M. Japonicus* familiar in Japanese art and legend.

This Chinese crab prefers brackish and sweet waters to the full sea littoral, and it is a problem how it has made its way to the Elbe.

The suggestion that it arrived in a ship is scouted, for in order to survive a substantial number of these crabs must have arrived simultaneously. A more plausible suggestion is that a quantity of immature crabs were among the barnacles and foul growths on a ship's bottom. The fact that the specimens already found are of different ages and sizes goes far to suggest that the invaders are already acclimatised and breeding in the Elbe waters.

# A Thousand Miles Up the River Amazon.

*If you care for an unusual and unconventional voyage, but not an uncomfortable one, here is a suggestion : Try South America.*

THE Amazon region has always been a lure to naturalists and scientific workers in many different fields of knowledge. A century ago the vast South American region was largely unknown, a land of mystery. To-day we know a little more about the general geography, the fauna and flora, but it is still virgin ground for the specialist in any particular branch, a land of infinite opportunity for the collector or observer.

It is not all of us who have the depth of purse, the leisure or the opportunity to go out with a properly organised scientific expedition, but here knocking at your doors is at least modified opportunity for a trip to the Amazon. The Booth Line are running a series of cruises from Liverpool to the Amazon *and one thousand miles up the river.*

A FAMILY OF EGRETS ON THEIR NEST.

**Unexplored.**

It is no ordinary trip, this, no high-speed passage from one civilised city to another, but a voyage to the very heart of South America—Manáos, a thousand miles inland from the Atlantic coast. On every side lies the tropical jungle still marked with that most challenging of all map legends, "unexplored." Once clear of Liverpool, a call at Oporto and at Lisbon, then straight out into the Atlantic till Madeira is reached ; that is the last contact with the Old World, and it is a lazy sunlit voyage crossing the Line till Pará River, one of the mouths of the Amazon, is sighted, so to the city of Pará.

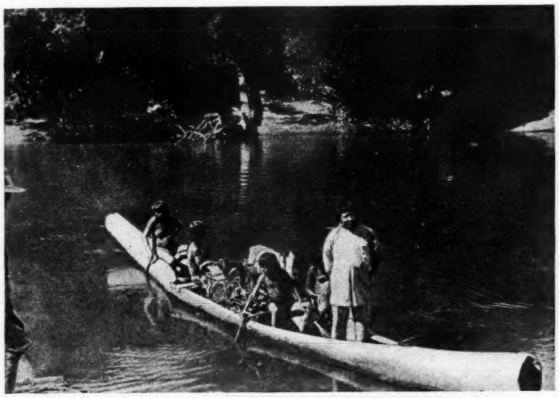
If you have never been anywhere in Latin America you must be prepared for a totally new and delightful atmosphere. An old leisurely and courteous civilisation living in enchanted cities with the a jungle stone's-throw from the walls. Palm trees, white-washed houses, native huts, bamboos, mangoes, and every shade of colour in the populace. There are the latest of modern shops and wonderful old Spanish buildings side by side. A city of contrasts and of indolent charm.

**Bird Paradise.**

Two days at Pará and the journey is resumed up the river. In an hour or two's steaming the channel narrows, and the ship passes up the narrows between a myriad bird- and insect-haunted islets. The entomologist has no need to land, for the butterfly clouds settle on the decks, and at night great velvety moths fly towards the lighted decks. So, touching at one or two small river stations, the trip is continued till Manáos is reached.

The city of Manáos is the centre from which the subsidiary river and forest expeditions are arranged. These latter must needs be undertaken in small local craft which can pass into the shallow waterways and lagoons covered with the great *Victoria Regia* lily. It is in these subsidiary expeditions that the naturalist, botanist or sportsman will find his greatest opportunities. Alligators, tapirs, monkeys and jaguars abound. The waters teem with strange fish and the *piraracu*, the largest freshwater fish known, can be harpooned ; incidentally this is the only known way of securing them, for no angler has yet discovered any bait, natural or artificial, which they will take.

The bird-lover will find every moment of interest, orioles, troupiors and humming birds nest in the



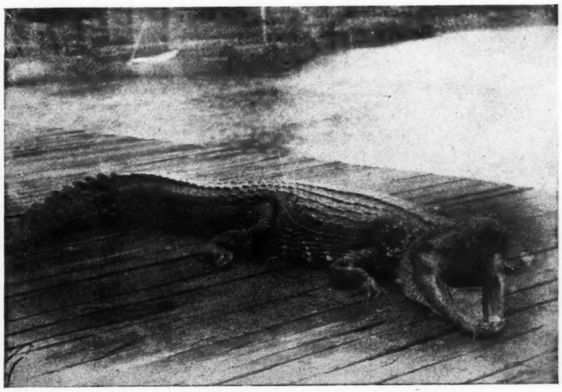
INDIANS IN A DUG-OUT CANOE ON ONE OF THE GREAT LAGOONS.

*VICTORIA REGIA* LILIES, WHOSE GIANT PADS WILL BEAR THE WEIGHT OF A BOY.

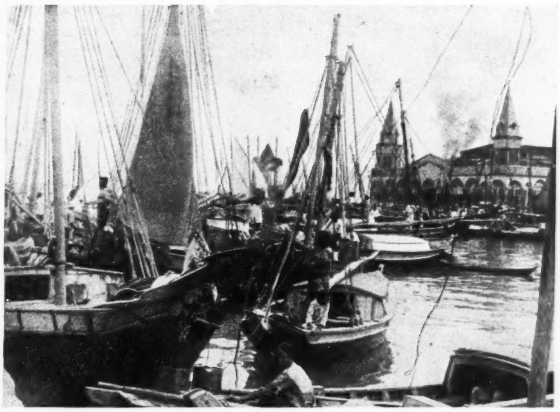
riverside jungle. Egrets, flamingoes and a host of water-birds haunt the mangroves and the wide lagoons.

In the same way, using Manáos as a base, trips can be made into the actual land forest zone beyond the waterways. Virgin forest, untouched by man, alive with tropical animal life and curtained with creepers and lianas, and the trees themselves hosts to orchids.

Here then, thanks to the enterprise of the Booth Line in running a special liner, the S.S. Hildebrand, from Liverpool to Manáos, is an opportunity for something distinctly out of the ordinary in travel tours. The Company, realising the opportunity that it affords to scientists, have completed special arrangements to meet their needs and every information concerning details of outfit and those important little matters one needs to know when preparing for a voyage in little-known lands can be obtained.



A GIANT ALLIGATOR SHOT ON THE BANK OF THE RIVER.



LIGHT RIVER CRAFT AT MÁNAOS HARBOUR.

## MEXICAN DISCOVERY OF 7,000-YEAR-OLD LIBRARY.

Prof. W. J. Niven, who has spent many years excavating near Mexico City, has unearthed a stone tablet library supposedly due to a long-lost pre-Aztec Mongoloid civilisation. He estimates the date as about 5000 B.C., basing the estimate on the successive lava flows which have covered the library. In addition to the inscribed tablets, which are in perfect condition and on their original shelves, masses of architectural drawings giving the plans of the temples and pyramids have also been found. These are painted in colours on the baked clay, and have not deteriorated through the ages.

# Shooting the Wind.

**By T. Riley, B.Sc.**

*Meteorologists have evolved a new and ingenious method of determining wind velocity above ground-level. The new meteorological gun is perhaps the germ of an important new instrument.*

ONE of the most interesting aspects of the study of any science is that of the instruments and apparatus by means of which observations are made. The astronomer and his telescope, and the bacteriologist and his microscope, are inseparable. Every science has its collection of instruments which preceding generations of workers have invented and improved. In fact, it may fairly be said that scientific progress is largely dependent upon the invention of new tools and instruments, which shall provide fresh links between the scientific experimenter and his subject of study.

Most of us are acquainted with the simpler of the instruments which the meteorologist employs in his study of the weather. The barometer, the thermometer, the rain-gauge, and probably the anemometer, are familiar to everyone. These, however, are too limited in scope to provide all the information that the meteorologist is anxious to obtain, and numerous other instruments have been designed for various special purposes. The latest addition to the weather student's apparatus is a "weather gun," by means of which he can literally "shoot the wind" in order to obtain very accurate information about it.

### Complex Effects.

The wind is by no means so simple a phenomenon as we are apt to think. Living as we do at the bottom of the atmospheric ocean, we are mainly interested in the air movements which occur at the bottom of the sea of air. And we are inclined to assume that every wind which affects us is part of an air current. which extends indefinitely upwards.

The meteorologist, as well as the airman, knows how different is the real state of affairs. The velocity of the wind varies from level to level. As we rise through the atmosphere, the wind may even change its direction as well as its speed. In fact, a calm at the earth's surface frequently exists at the same time as a strong current of air at some distance above it. To study the wind completely, therefore, we must observe it at more levels than one. It is in order to measure the wind velocity at various heights above the earth that the meteorological gun has been developed.

For observations at the ground-level, various types of anemometer have been invented—cup anemometers and pressure anemometers being the chief varieties. But when information is required of air movements above the earth, special instruments are required. Until recently, the chief method of investigating the movements of the upper air has been by means of "pilot balloons." These are small balloons, carrying neither observers nor instruments, which drift along with the current of air. Their movements are usually investigated by the use of the theodolite.

The weather gun was introduced, in the first place, because the weather conditions are not always favourable for the use of pilot balloons. For instance, they are quite unsuitable for the measurement of the wind above fog or low cloud—for the simple reason that they cannot be seen. The use of the weather gun is quite independent of such apparently unfavourable conditions as these.

The use of the gun can be very simply explained. If we point a gun vertically upwards, and fire a bullet from it, then if there is no wind to deflect it the bullet will rise vertically upwards with a velocity which will gradually diminish on account of the action of gravity. At length, the bullet will momentarily come to rest, and then it will retrace its steps downwards, with a gradually increasing velocity, until it reaches the muzzle of the gun again.

### Angle of Deflection.

If however, a wind is blowing, the pressure of the air will deflect the bullet, which will be carried along with the wind and will fall some distance away from the point from which it was fired. And it is pretty clear that it would not be difficult to obtain satisfactory information about the force of the wind, by simply noticing the distance which such a bullet would be carried away from the starting-point of its vertical flight.

In actual practice, however, it is found more convenient to use an alternative method. A full description of the method, and the calculations which are necessary, are given in an interesting paper on "How to observe the wind by shooting spheres upwards," by L. F. Richardson, B.A., F.Inst.P. (H.M. Stationery

Office. 9*d.* net). Considerations of public safety make it very undesirable to have bullets carried about indiscriminately by the wind, and even with the modified method which we shall briefly describe the experiments are generally carried out in the middle of an uninhabited field.

The gun and the observer are posted underneath a steel roof which provides a shelter for the observer, and also forms a target at which the gun is aimed. Instead of allowing the bullet to be carried away from the starting-point, the method employed is to tilt the muzzle of the gun a little towards the wind, just enough, in fact, to secure that the wind shall push the bullet back sufficiently to make it return with a "loud unmistakable bang" to the steel roof of the shelter from which it was fired. The amount the gun has to be tilted is a measure of the strength of the wind.

LEFT.—HELMETED OBSERVER FIRING AIR-GUN.
RIGHT.—OBSERVER UNDER SHELTER WITH NO. 3 SALOON GUN.
*Photo by permission of the Controller H.M. Stationery Office from Meteorological Office Professional Notes, Vol. III, 34.*

### Wind Velocities.

In order to find the wind velocity at different levels, the charge of powder to the gun is steadily increased. In this way the bullets are sent gradually higher and higher. For each standard charge of powder, the "tilt" of the gun is adjusted until the returning bullet hits the "target." The height attained by the bullet is determined by noting the time which elapses between the firing of the gun and the return of the bullet. For a height of 300 metres the time is about 16 seconds.

In this way we obtain a series of results for the "tilt" of the gun, in the case of bullets fired to gradually increasing heights. By means of a simple system of graphs, and a number of standard equations, these results can be used to give us the velocity of the wind at various heights. It is probably sufficient here to point out that, as the bullet gradually slows down during the course of its upward journey it passes very quickly through the lower levels of air, but is much slower in its movements as it draws near to the summit of its path. The tilt of the gun is, therefore, chiefly necessary in order to compensate for the deflection of the bullet in the upper part of its flight.

Experiments have been made with various kinds of guns, and with bullets of different sizes. The bullets used up to the present have been of three chief sizes, these being about as big as a lentil, a pea, and a cherry respectively. The larger and heavier balls are most suitable for the stronger winds, since they are less blown about by the wind, and move more nearly vertically. The smaller bullets give more sensitive results for the lighter winds.

### Bullet Variations.

The theory which Mr. Richardson has worked out only applies so far to projectiles which leave the muzzle without spin. For this reason rifles are unsuitable. The barrel of the gun must have a smooth bore, a fact which necessarily limits the choice. The chief kinds used have been smooth-bored air-guns for the smaller bullets, and fowling-pieces for the larger bullets. The greatest height to which bullets have been fired up to the present is about 720 metres. For this distance a bullet takes about 25 seconds to perform the double journey.

## NEW BLASTING METHOD.

A THIRTY per cent. saving in blasting explosives is effected by a new technique. The bore-holes are made longer than usual and the charge is tamped with fine-grained rock-dust in place of clay or wadding.

On explosion the rock-dust acts as a liquid tamping and seals the blast-hole so firmly that the bulk of gas is confined to the rock, and so shears a long pressure chamber splitting the rock along its cleavage lines farther than usual. The rock-dust seal is so efficient that paper bags placed in front of the blast-hole are not broken by the explosion.

# Power from the Poles.

**By Hugh Pollard.**

*Will Science find ways of utilizing the Polar coalfields, or be able to develop sources of electrical energy which can be "tapped" from the outer layers of the atmosphere and transformed into power by industrial centres in the temperate zones?*

IN the June issue of DISCOVERY Professor Rudmose Brown contributed a valuable article on "The Sovereignty of Polar Regions" showing how the Empire had been continuously augmented by the annexation of uninhabited wastes. But these bleak ice regions have a value which may perhaps be all-important to the future development of civilisation. They contain vast untapped mineral resources which are normally valueless for the reason that they are so far from habitable lands that they cannot be economically developed and their riches transported for utilization in the countries which need them.

That is how the matter stands at present. Now let us speculate on contingencies or possibilities of the future. Will the advance of scientific knowledge ever enable us to make practical use of these arctic and antarctic resources? Well, in a generation we have seen the birth and development of practical flight, and more recently radio-transmission of signals and speech, which have developed into a world-wide industry. The leading problem of the future is that of radio-transmission of electric power, and that is where the Polar regions possess particular interest.

### Known Resources.

Up there or down there—it just depends which Pole you are speaking of and where you are—there are vast undeveloped coal deposits and in some areas oil formations as well. These are the important minerals, and until a world famine in metals sets in—a not impossible contingency—we can afford to disregard the vast masses of copper, nickel, and even gold ores of the frozen north.

In addition to the coal there is a curious and valuable condition of atmospheric affairs which may prove to be all-important. The earth usually shown as a circle, and spoken of as a sphere, is in fact, comparable to a flattened orange in shape. Now centrifugal force acts on gaseous mixtures such as the atmosphere no less than on solids or liquids, and, since the air spreads out far from the circumference of the Equator, it follows that the depth of atmosphere at the Poles is far less than the depth at the Equator. In other words the shortest distance from Earth's surface to the layers of the outer or higher atmosphere is at the Poles. We thus find enormous potential power resources in coal which can only be utilized on the spot and cannot be shipped, and the short air route to the electrically desirable upper atmosphere situated in one and the same spot.

Now what do we know about radio-power transmission? The answer is meagre, but physicists and electrical engineers alike agree that it is only a matter of time, and probably short time too, before the problem is solved. After all, it is twenty-four years since Nikola Tesla first demonstrated the lighting of lamps by wireless power at a distance of some hundreds of feet, and where, in those days, Tesla was perhaps one of a score of scientists experimenting in this direction, to-day there are thousands. Our knowledge of the laws of radio-electricity and the tools to our hand in the shape of generators and apparatus have been vastly advanced in the period.

### Wireless Power.

Directional wireless is probably the pioneer to wireless power transmission. To-day, Marconi's system of parabolic minor transmission enables a message to be sent from England to the Argentine, and in place of the radiation of energy spreading over the usual 360° circle of dispersion, its energy and spread is confined to the tiny sector of a few degrees. This means not only secrecy for the message but also a rigid economy in power.

Modern theorists assume—though it cannot be said to be proven and must still be regarded as dangerous though fascinating ground—that with the decrease of atmospheric density as we go upward through the air toward space, we reach in a mile or two a region where universal loss-free electrical conduction can take place all round the 25,000-mile circuit of the earth. The thin air, almost vacuum, of the upper atmosphere is therefore taken to be a natural conductor just as air on the earth's surface is an ideal di-electric or insulator. The problem of world-power-transmission is to communicate electrical energy created on earth by vast water-power plants or by Polar generating stations fed by the Arctic mineral resources to this higher atmospheric conducting layer, and then to tap this energy for use in cities by means of vast towers topped by captive balloons or some similar arrangement of conductors.

Can it be done? A study of lightning phenomena suggests that the clue to establishing connection between earth and the outer conducting layer may possibly come from research on lightning. A lightning flash is a momentary natural establishment of the actual condition which scientists hope to establish as a permanent source of energy supply. It is an electric discharge of high voltage piercing the normally insulating layers of atmosphere.

Economical power transmission depends on transforming power at its source into high voltages. All the great electrical concerns in the world are studying the question of transformation of power up to enormous pressures of a million volts or more. Discharges exceeding this terrific energy have already been artificially produced, and show close similarities to natural lightning discharges.

Your scientific visionary thus builds up his concept of Polar power supply distributed cost-free by Nature all over the globe, and tapped where needed by collecting installations, which, in their turn, transform the high potential current back again to lower workaday pressures for ordinary use in the service of man.

*Impossible?*—— It must be a very bold or a very foolish man who will pledge himself to this denial when, year by year, we see new great discoveries conquering or harnessing Nature to our service.

*Is there anything in it?*—— There are four or five Arctic expeditions in the Polar regions now studying atmospheric conditions in high latitudes, among them the mystery of the aurora borealis. These various aspects of scientific research may have an important effect in the translation of the theories of to-day into the practical facts of to-morrow.

For the moment it is only a dream, a scientist's vision of the future—yet in the progress of real discovery established facts tread so close upon its heels that it is fascinatingly suggestive.

# Scottish Humour.

**By F. A. Hampton.**

*This most dangerous subject is boldly treated by the author, but on the whole he makes out a splendid case for the Scot.*

It is usually reckoned rather a humourless kind of pedantry to attempt to analyse a sense of humour, but it throws down a perpetual challenge and as it is a quality that may be presumed in the reader without fear of contradiction, so perhaps some slight interest in the nature of it may also be taken for granted, and at least that will-o'-the-wisp may be thrown into higher relief in contrast with the labour of pursuit.

The first and greatest difficulty is of definition, and it is suggested that humour, as an attitude towards life, is a consciously exaggerated depreciation of current values; without conscious exaggeration the attitude is merely cynical and carries with it a pretension of penetrating to the ultimate truth of things that is not compatible with a very acute sense of humour. On this theory we must accept as the most complete and consistent type of humourist, that exasperating fisherman of Stevenson's fable who persisted that "in my mind one thing is as good as another" till he succeeded in getting the King to part with his daughter in exchange for an old horseshoe. His awareness of his humour is perhaps suspect, so that he was nearly written off in the fable as a fool, a judgment that the more philosophical humourist very often complacently incurs. But humour cannot be truly said to be ever wholly unconscious, though when we meet on equal ground an individual who fails utterly to appreciate our standards then we get an effect of exaggerated depreciation and are tempted to look on him, in self-defence against his incomprehensibility, as an unconscious humourist. Medical missionaries among primitive races often record, with varying comment, that their patients have demanded payment for taking medicines or submitting to the operations and nursing that have cured them. This is an extreme example of what has been called unconscious humour, although the savage is really acting quite seriously according to his own peculiar standards, and the only humour in the situation would be provided by the physician if he could afford to accept the Erewhonian standard of his patients with adequate liberality. Curiously enough, civilised patients, though possibly acting from different motives, are liable to expect a return of interest and support from the physician to whom they attribute their cure.

It is along these lines of treating him as an unconscious humourist that the Southerner gets so much amusement, if proverbially little else, out of the Scotsman who tends to level down all values to a practical, logical standard that often differs very widely from our own perhaps slightly sentimentalised and conventional appreciation of them. But he is often

so very much aware, with a certain restrained gusto, of the gulf between his own values and those that he affects to disparage, that the unconsciousness of his humour is very much open to doubt, and when he writes from Palestine, "Dear——, I am in Bethlehem where Jesus Christ was born, but I wish I was back in Glasgow where I was born," it would be risky to admire his naiveté without suspecting that he was pricking the bubble of someone's spurious enthusiasm. Again, it is significant to find in how many "Scotch" stories the Scotsman emerges master of the situation, and the suspicion creeps in that they are often of home manufacture and their point not always fully grasped by the Southerner who retails them.

### Real Capacity.

Of the Scotsman's capacity for humour there can be no real doubt, however much the rest of the world may be stung into deriding it by a failure to obtain from him the faintest approbation of exotic wit and whimsicality. On the other hand, it is interesting to find the Englishman quite consistently accused by French and Americans of lacking a sense of humour, though it is perhaps reassuring, in this instance at least, to reflect that such a charge is very commonly made against people or nations whose solid qualities are secretly envied.

It is the Scotsman's real or supposed parsimony that provides, of course, the most abundant material for "Scotch" stories, but the insistence on this theme is not quite obviously explicable and it is tempting to think that here the element of envy comes in. For if this type of story is examined, it will be found that in quite a large number the Scotsman behaves very much as we should like, in a less emphatic way, to do ourselves.

But the Englishman's vanity seems especially susceptible where money is concerned, and it is not without reason that he has acquired on the Continent a reputation for wealth and prodigality that, however inconvenient, is difficult for his amour propre to disclaim. The Scotsman's vanity is of a more solid sort and he does not reckon the gesture of largesse worth the price, nor the fiction of unlimited means worth sustaining. There is a story (for which no special mirth-provoking quality is claimed) of a Scotsman who took a friend to one of London's more imposing restaurants, ordered a bottle of Bass and two glasses and, producing a packet of sandwiches, forestalled the criticism of the manager by inquiring sternly of him "why there was nae band playing?" and, although the Scotsman is the accepted butt of the story, yet if we subtract the element of caricature he is only behaving with admirable strength of mind in the kind of situation that is apt to bring out all the weakness of the Englishman where wealth and convention threaten to dominate him. The story has a curious likeness to a dream, of the kind that could be interpreted (according to the Freudian formula) as the fantastic fulfilment of a repressed wish, with some degree of plausibility.

By laughing at the Scotsman's foible we are able to reinforce the barrier that protects us from realising the insincerity or sentimentality of our own conscious standpoint, though at the same time, by our very insistence on the theme, we pay homage to the point of view that we caricature.

It is not implied that the humourist's point of view is the correct one—he would be the last to claim that for it—but by extravagantly belittling the current values, or by inverting them altogether, he very often makes a peculiarly effective criticism according to the immemorial method of irony and satire.

Humour also serves a more private purpose in protecting the individual against reality; the humour of the fighting man during the War, that seemed, to one American observer at least, a morbid flippancy, was conspicuously an attempt to take some of the horror out of reality by denying its real implication. To call a trench-mortar bomb a flying pig or a pineapple did not imply any contempt for them, but it did do something to prevent the mind from being obsessed by the horror of their effects. This function of humour explains why it is so often highly developed in rather unhappy individuals and comparatively rare in the placidly contented.

### Solid Sense.

The Scotsman's humour, his not quite unconscious extravagance in belittling the claims of sentiment and emotion, may, it is suggested, serve him as a protection against his repressed sentimentality, a quality so strong that he dare not admit its existence in everyday life, however exuberantly it may well up in his cups or in the perfervour of his patriotism.

His literalness guards him against being deluded into false values by a powerful imagination that he prefers to exercise in the non-compromising sphere of metaphysics. His humourously exaggerated economy may also serve as a protection, though it requires a certain courage to suggest that he is, even unconsciously, a would-be spendthrift; yet we know that he cherishes clear-cut and expensive ideals that demand the sacrifice of minor indulgencies and he is trustworthily recorded to have left his purse behind before going to a missionary meeting as a safeguard against "any ill-considered act of charity."

# Book Reviews.

## WHO WROTE THE HOMERIC POEMS ?

*The Homer of Aristotle.* By D. S. MARGOLIOUTH. (Oxford : Basil Blackwell, 1923. 10s. 6*d.* net).

About the year 170 B.C. an Alexandrian grammarian suggested that the author of the *Iliad* could not also have written the *Odyssey*, and the "Homeric question" became, and has since remained, one of the greatest of literary problems. Already by the middle of the 1st century A.D. Seneca regarded it as a question for the discussion of which life was too short. Professor Margoliouth in the book now before us offers material which, if we could accept it, would set the controversy at rest for ever.

We have become accustomed by now to those ingenious persons who discover that great writers wrote masterpieces, such as the plays of Shakespeare, in order to embody in them literary secrets which none but these ingenious persons were destined to unravel. Such cryptographic methods Professor Margoliouth has now applied to the opening lines of the extant Greek plays and to the *Iliad* and *Odyssey*. He has "discovered" that the first eight lines of any Greek play contain : in lines 1 and 2 the "signature," giving the author's name or description ; in lines 3 and 4 the "chronogram," giving the date ; in lines 5 and 6 the "ascription," an invocation of the goddess Athena ; and in lines 7 and 8 the "admonition," a warning that the cipher has come to an end. His method of "proving" this is to take the letters of each pair of lines and rearrange them in an anagram.

It must be admitted that the author has shown extraordinary ingenuity, but a little close examination soon destroys one's faith in the infallibility of his method. The truth of the matter is that if one is given sixty assorted letters (the average content of two iambic lines) and sufficient leisure—Professor Margoliouth admits that some of his "solutions" have taken several hours—and has made up one's mind what one wants to say, it is always possible to compose a pair of iambic lines which will give some sort of sense of the kind one proposes. We have experimented with the first two lines of the *Œdipus Tyrannus* of Sophocles, and have found it possible to make up an anagram to the effect that the author is Euripides.

Moreover, Professor Margoliouth's "solutions" will not always bear examination. For instance, that of the "signature" of the *Electra* of Sophocles contains only 58 letters, while the original has 61 ; it is thus no anagram at all.

The "Homeric Cipher" is still more amazing. Italicus, the Latin translator of Homer, embodied his name in the initial letters of the first eight lines of his version of the *Iliad*. This, according to Professor Margoliouth, must be a simplification of something which he found in the original ; *therefore*, the first 10 lines of the *Iliad* must be divided up into vertical columns in groups of two letters, and the contents of each column rearranged to form a continuous anagram ! The result is eight *iambic* lines displaying the most extraordinary Greek. That Homer should ever have written iambics is in itself a remarkable theory ; but he might have been pardoned if the result had been at all intelligible.

The following is the translation of the first four lines :—"*Into the voice of Homer of Tos, expelling from the bounds, O gracious* (the Greek word means "destructive") *deity, the contrary fiends, enter even as ye entered the laments of Orpheus ; waters stopped, like fire they kindled strange lands.*" If anyone can conceive that Homer or any other poet could speak of "water kindling strange lands like fire," he may be able to bring himself to believe in the "Homeric Cipher."

The "solution" of the Preface to the *Odyssey* by similar methods produces some astounding lines ; anyone who can translate them without Professor Margoliouth's "crib" merits some substantial reward.

The general deduction to be drawn from the "deciphered" Prefaces is that both the *Iliad* and the *Odyssey* were written by Homer of Tos to be read in bed by a certain Æneades, apparently a descendant of Æneas, who, flying in the face of all historical evidence, revived the glories of pre-war Troy !

We cannot accept the "ciphers" ; but there is no lover of the Homeric poems who would not welcome the proof that Homer, the blind bard of immortal song, really existed in the form of one man and was author of the epics which bear his name. Does the internal evidence of the poems leave any place for a personal Homer ? The *Iliad* and *Odyssey*, which, as Professor Margoliouth does well to insist, formed the scriptures of the Greeks, existed in the 5th century B.C. in substantially their present form and were attributed to one author, Homer ; but criticism has found so many differences of language and custom, and so many discrepancies of narrative, that it is no longer possible to believe that the two epics were conceived and written by one single author. Again, within each poem we find inconsistencies of narrative, irrelevant episodes and dialectical variations. Considered as language we know now that "Homeric Greek" is an artificial combination of two quite different dialects (Æolic and Ionic), such as no one community ever spoke. All this points to the existence of various strata, i.e., portions composed at different epochs. In explanation of the dialectical peculiarities, it is now generally held that the poems had their origin amongst the Achæans of European Greece, who subsequently carried them over to Asia Minor, when they migrated to escape the Dorian invasion, and that the poems were then rewritten in Ionic by the Ionian settlers who followed.

The *Iliad* seems to consist of three principal strata : first, a story of the hero Achilles, his quarrel with the Greek generalissimo Agamemnon and his refusal to go to fight, the gallantry of Patroclus who takes his friend's place and is slain by Hector, and Achilles' vengeance upon Hector (Book I, IX, XVI and parts of XIX and XXII) ; secondly, a stratum devoted to glorification of heroes belonging to the other great Achæan families, the addition of which has converted the *Iliad* into a national poem instead of the epic of a single hero ; and thirdly, other additions made probably after the migration into Asia, of which the most remarkable is the "Catalogue of the Ships" in Book II. The *Odyssey* contains fewer interpolations and confines itself to the subject of the wanderings of Odysseus on his way home from Troy to Greece. It has greater artistic unity than the *Iliad*, but is generally held to be later in date and to fall between the *Iliad* and the later narrative verse which we call the *Cyclic Poems*, of which only fragments survive.

As Professor Jebb has pointed out, the Homeric poems mark the end, not the beginning, of a poetical epoch, the high watermark of a school of poetry, which began with short and simple lays and ended in the long heroic epic. If we are to find a place for a personal Homer, it is to be either as the author of the

original *Achilleid* or of the *Odyssey*, or else as the poet who, using material which he found ready to hand, evolved the first continuous epic, the *Iliad*.

But after all, while the "Homeric Question" will always possess a fascinating interest for the student, the *Iliad* and *Odyssey* in themselves possess a human interest for every reader, and an incomparable charm which makes them unique in literature; they take us, to use Professor Murray's words, "into a world somehow more splendid than any created by other men." The first epics, they still remain the greatest.

*Atoms and Rays.* By SIR OLIVER LODGE, F.R.S. (Ernest Benn, Ltd. 21*s.* net).

To the student of Physics, as well as to everyone who is interested in Physical Science, the appearance of a new publication by Sir Oliver Lodge is always a memorable event. He remarks in his preface to this book that "when a series of discoveries arouses enthusiasm, it is only natural for someone with a teacher's instinct to try to interest all intelligent people, and not only the expert few, in the marvels that are being revealed." In Sir Oliver Lodge we have a scientist whose teaching powers, as well as his teaching instinct, have seldom been equalled.

The subject-matter of this book would not usually be regarded as easy to understand by the average mind. It aims at providing "an introduction to modern views on atomic structure and radiation." These are matters which can usually only be described in very technical language, with an accompaniment of mathematical arguments that are beyond the understanding of all save the few. Sir Oliver Lodge makes the atom as real and tangible a thing as the solar system. The atom consists of "sun and planets in miniature," and the whole subject of atomic structure, and the development of our knowledge in regard to it, is looked upon as an "introduction to atomic astronomy."

The book starts with a stimulating description of the constitution of matter, that leads us almost immediately to the formation of a vivid mental picture of a typical atom, and a clear view of the essential differences between the atoms of the different elements. We are introduced to the ether, both as the "welding medium" that holds the particles of the atom together, and also the medium through which radiation, visible and invisible, takes place whenever the motion of an electron within the atom changes.

The discussion of different kinds of atom, and of atoms under various conditions, leads us to consider unstable atoms, and the effect of "atomic projectiles" in producing the disintegration of the atom, a result which has been achieved experimentally by Sir Ernest Rutherford. The discussion of the energy of the atom leads to a fascinating chapter on the possibility of "harnessing the atom." An account is then given of the methods of investigating the atom, which includes a strikingly clear explanation of the X-ray spectrometer, the use of which depends upon the fact that the wave-length of X-rays is as small as the atom itself.

The remainder of the book follows two main lines. In the first place, the radiation from the atom is considered in relation to the spectrum, and we are shown the steps by which the complication of lines in the spectrum of any element has been reduced to order, and has been utilised to give us a glimpse into the "possible orbits" of the electrons within each kind of atom.

Secondly, there is gradually developed, side by side with this wonderfully simple theory of the spectrum, the modern view of the energy of the atom, and the conditions under which it is released in order to give us the various types of radiation. In this connection, there is gradually developed a simple and satisfactory idea of the recently introduced physical constant, the *Quantum*, which in Sir Oliver Lodge's opinion is quite as important as "Relativity." The radiation emitted by atoms is distributed "in packets," each of which is an energy unit—a discovery made by Professor Max Planck in 1900, which has thrown a flood of light upon the changes that take place within the atom itself.

It is impossible to give any adequate idea of the full range of topics which Sir Oliver touches upon and illuminates in the course of this book. The general impression after reading it is, however, one of satisfaction that one has at last been able to see beyond and within the atom, and that although its essential features are no longer mysterious, they are none the less marvellous. It is typical of the book that the exposition leads to a climax, in a thought-provoking final chapter which deals with possible applications in the future. "Few can have suspected, in the reaction steam-jet of Hero of Alexandria, the germ of a ten-thousand horse-power Parsons steam turbine; and it is still more difficult to detect in the electric whirligig any fore-shadowing of the power of the future."

This is the concluding sentence, but the whole book is written in a similar vein. Apart from the feeling which it gives us that at last we understand things that we did not expect to be able to grasp so clearly and completely, the student will be conscious, for many a day after reading it, of a number of lines of thought and speculation that have been suggested to him by his study, and which this masterpiece of exposition has fitted him to follow up and appreciate.

*Human Physiology: A Practical Course.* By C. G. DOUGLAS, C.M.G., M.C., D.M., F.R.S. and T. G. PRIESTLEY, M.C., D.M. (Oxford University Press. 12*s.* 6*d.* net).

Experimental methods of investigation of physiological problems are of vital importance in the thorough comprehension of disease. Above all it is important to have a clear knowledge and understanding of the normal or healthy body. This book is therefore designed as a textbook for the use of students and outlines experimental work which can be carried out in the laboratory. The chapters cover the physiological experiments on the respiratory system, the blood circulation and constituents including blood gases, the kidneys and the alimentary canal.

The work is a valuable addition to the excellent series of medical books published by the Oxford University Press, and the authors are to be congratulated on having produced an excellent textbook not only for the medical student, but also for the student of physiology in branches distinct from the medical and clinical schools.

*The Biology of Flowering Plants.* By MACGREGOR SKENE, D.Sc. (Sidgwick & Jackson. 16*s.* net).

The botanist will welcome this volume which bridges the gap between the purely botanical and the physiological sides of his subject. The book gives the student a clear idea of the complex manner in which a flowering plant lives as an individual rather than as a member of a community. The root system and special modes of nutrition are dealt with, and a particularly good section deals with the whole process of assimilation and transpiration.

The no less important functions of protection are also considered, and reproduction and the dispersal of seed are treated with an unusual wealth of illustration.

on. In
le and
nstant,
uite as
atoms
unit—
ch has
within

range
in the
g it is,
ble to
sential
s mar-
ads to
s with
ected,
rm of
l it is
fore-

ritten
s that
able
cious,
ought
tudy,
ollow

GLAS,
M.C.,

gical
nsion
ledge
book
and
the
nents
uents

es of
and
d an
also
the

ENE,

gap
his
plex
ther
ecial
tion
n.
con-
ted